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[COMMITTEE PRINT]

THE FUTURE OF AVIATION

REPORT

PREPARED BY THE

SUBCOMMITTEE ON
AVIATION AND TRANSPORTATION R. & D.

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-FOURTH CONGRESS
SECOND SESSION
Serial EE

VOLUME I

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LETTER OF SUBMITTAL

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

Hon. Olin E. Teague,
Chairman, Committee on Science and Technology, U.S. House of Representatives, Washington, D.C.

Dear Mr. Chairman: The aviation industry in this country has been one of our greatest national achievements. It has grown from a mere curiosity to become an integral part of our way of life. It has had the most profound effect on commerce, on national defense and on our perception of the world.

Most experts agree that, within the past few years, aviation has become a mature industry. As such, its future directions, and consequently the direction of aeronautical R&D, will be determined as much by economic, regulatory and institutional questions as by technological opportunities.

With this in mind, the Subcommittee on Aviation and Transportation R&D undertook a comprehensive examination of the future of aviation. Our objective is to lay the basis for a national civil aviation R&D policy. In doing so I believe we can make a thoughtful and useful legislative input into national transportation policy.

In addition to formal hearings, the Subcommittee garnered a large number of contributed papers from a variety of experts. Witnesses and contributors of papers were carefully selected to assure a thorough discussion of the many issues related to R&D policy.

This report summarizes both the hearings and contributed papers, published as separate committee documents, and offers findings and recommendations based on the testimony and papers.

Sincerely,

Dale Milford,
Chairman, Subcommittee on
Aviation and Transportation R. & D.

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FINDINGS AND RECOMMENDATIONS

Finding 1

Aeronautics and the economic health of the aviation industry is clearly a national concern and the maintenance of United States predominance as the world's leading aircraft manufacturer and supplier is in the national interest. This is evident when considering that:

1. Over a million direct American jobs result from aviation manufacturing, airline operations, and groundbased aeronautical activities.
2. Many additional service and support jobs are created as a result of direct aviation activities.
3. Export sales of aeronautical products rank first among all manufactured goods, exceeded only by agricultural products.
4. Safe, reliable, fast air transportation is essential to our national way of life.
5. Aeronautical technology has been applied to a wide variety of beneficial products from industries totally unrelated to aviation.
6. Aviation has made a vital contribution to our national defense.
7. Aeronautical design teams, laboratories, and production facilities represent an irreplaceable national asset.

Recommendation

National policy must clearly declare that maintenance of the United States' preeminence in aeronautics is absolutely vital to the national interest.

Finding 2

Research and development of new aeronautical technologies is vital to the future of the American aviation industry because:

1. Today's investments in R&D are the single most important determinant of the nation's future air transportation options.
2. Extensive R&D is a prerequisite to the delivery of the new aviation products that are needed to retain our worldwide commercial leadership.

Recommendation

The Federal Government must recognize the direct relationship between well-planned, effective R&D and the future health of the aviation industry through creation of a National Civil Aviation R&D Policy.

Finding 3

Current Government-sponsored civil aeronautical research and development efforts have failed to respond to changing conditions and cannot succeed in maintaining American technical superiority in the future. This is evidenced in the following:

1. Current R&D is primarily limited to technology development and is seldom extended to the point where results can be readily applied by industry.

2. Government-sponsored aeronautical R&D often has been oriented toward short-term goals which failed to recognize that development of viable new generation air transport aircraft, engines and products now requires several years and substantial long-term financial commitments for success.

3. The costs of developing new aircraft and engines are approaching the net worth of individual manufacturers, seriously inhibiting such projects.

4. Foreign governments are spending increasing sums on aeronautical R&D (often exceeding U.S. spending), posing a real threat to continued U.S. supremacy.

Recommendation

Government-sponsored aeronautical research, development, and demonstration (R,D&D) programs and activities must be totally restructured and reoriented into a new and comprehensive national effort that will:

(1) Be coordinated with other modes of transportation and given focus in the National Transportation Policy.

(2) Expand past practices of conducting only basic research and technology development into other areas of aeronautical development that are beyond the capacity of private enterprise:

(3) In close coordination with private enterprise, establish long-term stabilized goals and identify the Federal resources needed to fulfill these goals.

FINDING 4

Foreign nations are clearly making a major effort to capture a greater share of the very large future world civil transport market, currently dominated by the U.S. They are especially interested in increasing their penetration of the European market. This determination is manifested in the following:

1. Foreign government contributions to the research, development, testing, and marketing of new aircraft and aviation technologies, now exceed those of the United States.

2. There has been considerable growth in the size of the European aerospace industry as indicated by markedly increased employment figures.

3. The Europeans and the Russians have each developed, and are now operating, civil supersonic air transport aircraft in regular commercial service.

4. Recent European attempts at forming joint ventures have achieved a new level of success, raising, for the first time, the possibility of formidable foreign aero consortia.

5. Political pressure by European governments on their national carriers to "buy European" may become more widespread.

6. Recent products have demonstrated considerable competitive appeal and are being offered to American air carriers on very favorable terms.

Recommendation

The United States Government can no longer ignore foreign government subsidies to their aircraft industries and air carrier operations. The United States must:

1. **Substantially boost its efforts in the development of new technology.**
2. **Accelerate the conversion of new technology into operating hardware.**
3. **Reevaluate national policy toward the development of supersonic air transports.**
4. **Reevaluate national policy toward the export of American-developed technology.**
5. **Closely examine the national interest involved in joint-ventures between American manufacturers and foreign subsidized firms.**
6. **Reexamine present treaties involving agreements for the operation of international air carrier flights.**

FINDING 5

From the very earliest days of civil aviation there has been a vast and a rich transfer of technology and hardware from the research and development activities of military aviation. While some technology fall-out is expected to continue in the future, there will be a considerable decrease in the direct transfer of easily adaptable hardware for the following reasons:

1. Present military aeronautical R&D often involves increasingly complex total "weapons systems" that are designed for specific missions and therefore cannot be easily nor economically adapted to civil use.
2. The design aims, goals, and missions of military supersonic and hypersonic fighter aircraft will have little in common with civil aircraft needs.
3. Military aircraft designs are not strongly driven by such civil concerns as noise and pollution.

Recommendation

Federally-sponsored civil aeronautical research, development and demonstration efforts must be expanded to compensate for reduced military fall-out and must be pursued independently, with appropriate national priority.

FINDING 6

In the past, U.S. air carriers have always been the "launching customers" that prompted civil air transport aircraft manufacturers to design and manufacture new generation aircraft. Because of the confluence of several adverse factors, American air carriers are now unable to provide the necessary guarantees to enable a manufacturer to produce a new generation aircraft.

1. Recent general economic conditions have severely depressed the profits of air carriers, leaving them with insufficient capital to initiate a fleet order for new aircraft.
2. The industry's traffic volume projections in the late 1950's and early 1960's were overly optimistic, resulting in over purchase

of new equipment (excess capacity), that must be operated at reduced efficiency or disposed of at a financial loss.

3. All air carriers have been affected by a leveling off of the previous trend that saw substantial airline expansion at the expense of other transportation modes.

4. Future growth is expected to be related primarily to growth of the economy.

5. All air carriers have been seriously affected by inflation, especially the tripling of fuel prices that has occurred within the past three years.

6. Major financial institutions and investors have found air carriers to be unattractive, making it impossible for them to form the capital needed for new equipment purchases.

Recommendation

The National Civil Aviation R&D policy must recognize that the single most important ingredient needed to open the way for development of new generation aircraft is the ability of U.S. air carriers to purchase new equipment.

FINDING 7

The present national transportation system has been shaped as much by government action as it has by free market forces. In the past, government action in the transportation field has been characterized by a patchwork approach to R&D and a labyrinth of direct and indirect subsidies. Without a coordinated effort to guide government actions in the future, this process will continue and inevitably will yield a result that fails to serve the best overall interests of the nation.

Recommendation

The Subcommittee believes that the Department of Transportation should take a forceful leadership role in providing a focus for civil aviation R&D. It can do this by addressing the proper role of aviation within the national transportation system, especially the classes of markets that can be best served by air. Such activity should be accomplished with full participation by all those affected and should include the necessary flexibility to respond to changing conditions, and new R&D derived opportunities.

FINDING 8

Current institutional arrangements are inadequate to provide a systematic aviation input into national planning and decision-making. This is evident by the following:

1. There are many examples of government action in diverse areas including tax law, regulation and trade policy that have had profound and often unanticipated side effects on the aeronautical industry, and thereby the R&D process.

2. The full potential of civil fall-out from military aircraft developments have not been realized, in part because civil requirements were not focused nor factored into such developments during the RD&D phases.

3. The recommendations of past studies of civil aviation R&D policy have been frequently ignored.

Recommendation

A strong centralized policy-level authority, with jurisdiction over all federal agencies dealing directly and indirectly with civil aviation must be established. Such an office would:

1. **Coordinate all Government-sponsored aeronautical R&D to assure that the national interest is served.**
2. **Oversee Government actions in diverse areas such as regulation, trade policy and tax law to assess possible effects on aviation.**
3. **Provide a coordinated aviation input into national transportation policy and planning.**

FINDING 9

The Subcommittee found a wide range of available government measures, beyond the traditional role of technology development, which would assist the American aircraft industry in developing new generation aircraft. Among these are:

1. Reduction of regulatory and trade barriers that now prevent or hinder application of new technology in the marketing of aircraft and aviation products.
2. Extension of the traditional federal role of development of new materials, concepts, and processes to a stage where they can be readily applied by industry.
3. Federally-sponsored world-wide market surveys to aid American industries in the early identification of aircraft demand.
4. Government-sponsored design competitions of new generation air transport aircraft and engines.
5. Government assistance to American industries, in the form of innovative funding mechanisms that will ease the cost of developing and testing new generation aircraft and engines.
6. Adaptation of the military concept of independent R&D funds to solve civil aeronautical problems that are of national concern.

Recommendation

While the Subcommittee felt that it did not have sufficient information to offer a specific formula, the evidence strongly indicates the need for accelerated federal support in the areas identified. Therefore, the Subcommittee recommends that:

1. **The Secretary of Transportation assemble a study group, consisting of knowledgeable professionals from each Federal agency involved in aeronautics and appropriate individuals from industry.**
2. **The study group carefully evaluate the potential and the implications of the listed measures, and, when appropriate, reflect their findings in the National Civil Aviation R&D policy.**
3. **The study group report their findings and recommendations to the Secretary and to the Subcommittee at the earliest practical date.**

Finding 10

There is an increasing trend among U.S. aircraft and engine manufacturers to seek partnerships and joint ventures with foreign companies in developing new products. The reasons for this are:

1. The conviction on the part of U.S. manufacturers that the world's industrialized nations, especially the European countries, are committed to developing new aircraft.
2. A fear that foreign governments will direct procurement of locally produced aircraft by their national airlines.
3. To retain market access in Europe, U.S. manufacturers feel that they must be prepared to cooperate with overseas companies.
4. A need for American aircraft manufacturers to augment domestic sources of capital to help defray the prohibitive costs involved in the design and development of new generation air transport aircraft and engines.

Recommendation

The Subcommittee believes that the trend toward foreign joint ventures may be an overly conservative reaction on the part of American manufacturers aimed at assuring market access in a few European countries. In the past, the American aircraft industry had maintained world preeminence because of superior technology, better manufacturing processes, extensive marketing and servicing organizations and extremely reliable equipment, all of which have combined to produce superior aircraft at lower prices. Retention of these factors is necessary to insure U.S. dominance. In lieu of joint ventures, the Subcommittee recommends:

1. **Additional Federal support in the R,D&D of new generation American air transport aircraft and engines.**
2. **Federal action to accelerate the delivery of new technology of the marketplace.**

Finding 11

The Subcommittee found that some aspects of foreign joint ventures are disadvantageous to the national interest because:

1. Technology that is often derived at tax payer expense is exported to competing nations.
2. American jobs may be lost to foreign countries.
3. The national defense may be endangered through the conveyance of advanced technology to potential adversaries.
4. American technological progress will be reduced in the areas where the foreign partners are working.
5. American customers will become dependent on foreign suppliers.

Recommendation

The issue of foreign joint ventures is a complex one requiring the attention of several Congressional Committees. Therefore, this Subcommittee will not presume to address the entire question; but will concentrate on those aspects that affect the R&D process.

1. Some form of government assistance must be provided to ease the legitimate problems of capital formation that are now forcing U.S. manufacturers to go overseas in joint ventures.

2. Maximum efforts must be made to closely control the export of new technology that has been developed under government sponsorship.

3. An economic study must be made to determine the impact on American jobs and our balance of trade that will result from the formation of joint ventures.

FINDING 12

The supersonic transport field has been abandoned to the Europeans and the Russians. The United States has the ability to readily develop the technology needed to build an economically-viable, environmentally-acceptable and fuel-efficient advanced supersonic transport. The early experience with regular commercial operation of supersonic air transport aircraft shows a high degree of passenger acceptance.

Recommendation

It is clearly in the national interest for the U.S. to build an environmentally acceptable, fuel efficient and economically viable supersonic air transport aircraft. Government action in the near term should be aimed at accelerating the technology availability date for such a project and at reducing barriers to development by the private sector.

FINDING 13

The most important need for aeronautical R&D, in the near term, is in the area of increased operating efficiency. Improvements in fuel efficiency and other operating factors are absolutely necessary for the long-term health of U.S. air carriers and for the competitive position of U.S. manufacturers.

Recommendation

The Subcommittee heartily endorses the objectives of the NASA Aircraft Energy Efficiency program, but urges that its scope be expanded so that the results may be readily and quickly applied by industry without undue risks.

FINDING 14

Regulation, per se, is not within the jurisdiction of this Subcommittee and we have no desire to enter the debate surrounding the various economic regulatory reform proposals now before the Congress. Nevertheless, there is ample evidence to show that the R&D process and consequently the U.S. technological position is affected adversely by the current regulatory structure:

1. There are examples in which regulation has inhibited the development of new aeronautical technology.

2. Delays in promulgating new rules and regulations have frequently hindered the R&D process.

3. The current regulatory structure has restricted or, in some cases, overstimulated airline competition which has in turn had adverse effects on the R&D process.

4. In some cases regulation has unnecessarily hindered the formation of capital by airlines which in turn adversely affects the R&D process.

Recommendation

The Subcommittee favors the early modernization of economic regulations and the streamlining of promulgation procedures which would permit appropriate competition and thereby enhance the development of new technology. This action should assure that quality service is provided to the public. Furthermore, it should be completed quickly to restore the stability that is necessary for investor confidence in U.S. airlines.

FINDING 15

Aircraft noise and pollution along with land use considerations represent increasingly important constraints on the growth of aviation, particularly the needed expansion of airport capacity.

Recommendation

Civil aviation R&D policy must emphasize the need to develop and quickly apply new technology to aircraft and airports in response to requirements for reduced emissions and noise and more effective land use control.

FINDING 16

Manufacturers have had little guidance that would require them to incorporate the most advanced noise and emission suppression technology in their designs for future aircraft and engines. Without adequate regulatory standards that precede the development of new aircraft, design tradeoffs are generally made which favor other parameters. Furthermore, the affect of late regulatory action has been to increase development and production costs.

Recommendation

FAA, EPA and other regulatory agencies must develop mechanisms to assure that regulatory standards are developed in time to permit the incorporation of the best available noise and emission suppression technology in future aircraft and engines.

INTRODUCTION

The airplane is one of but a handful of man's innovations that have fundamentally altered his way of life. It has revolutionized his commerce, his warfare and, perhaps even more importantly, his perceptions of the world.

Aviation has grown from an awkward curiosity into a major industry. Today it represents an essential mode of transportation, a vital element of national defense, a necessary ingredient in business and a popular form of recreation.

In the United States we have the finest air transportation system in the world. There are 12,700 airports across the country, served by 2,500 air carrier aircraft and used by 160,000 general aviation aircraft. The air carrier industry alone has invested capital of $18 billion which, generates $11 to $15 billion in revenues annually, and provides 300,000 direct jobs.

General aviation has added many more billions in revenue and thousands of additional jobs.

From the first days of powered flight, the United States has played a leading role in the development of aviation. Through the steady application of newer technology, we have continually developed faster, safer, larger, and more reliable aircraft.

In recent years, the United States has been absolutely preeminent in the world marketplace. Today, 85 percent of the commercial aircraft flying in the free world are of U.S. manufacture. The economic benefits of this have been very substantial. In 1975 the aviation manufacturing industry generated $30 billion in revenue and provided over 400,000 jobs. We exported nearly $8 billion in aerospace products, an amount that is second only to agriculture.

Thus it is clear that the national interest is involved in the future of aviation. Yet, a complex array of new problems has emerged to confront the industry. Foreign challenges to U.S. technological leadership are gathering momentum. Airline earnings have declined to the point where they can no longer provide the traditional stimulus for development of new aircraft. And, research and development costs for sophisticated new equipment have climbed beyond the means of individual companies.

Charged with the legislative responsibility for civil aviation R. & D., and therefore in large part for its future directions, the Subcommittee on Aviation and Transportation R. & D. undertook a comprehensive examination of the "Future of Aviation." The purpose was to lay the basis for a national civil aviation R. & D. policy and in doing so to make a useful contribution to national transportation policy.

The Subcommittee is well aware of the many fine studies of this subject conducted in the past. Among these are the Civil Aviation R. & D. Study of 1968 by the Aeronautics and Space Engineering

Board (ASEB), the Civil Aviation R. & D. Policy Study (CARD Study) of 1971, the report on R. & D. Contributions to Aviation Progress (RADCAP) in 1972, and the Aviation Advisory Commission report in 1973. Nevertheless, constraints, projections and opportunities change with time. For example, the effect of significant increases in the costs of fuel is a new factor that must concern policymakers. Therefore, these previous efforts must be constantly reexamined and built upon to assure a policy that is fully responsive to conditions.

The Subcommittee found during its investigation that aviation is a mature industry. Although in younger industries such as the space program, R. & D. policymakers are primarily concerned with technological possibilities, this is no longer the case in aviation. Today, a wide variety of issues bear on the direction and the success of R. & D. policy. Accordingly, the Subcommittee expanded its examination to include economic and institutional issues, the civil benefits of military R. & D., the role of aviation in the national transportation system, the status of foreign competition, and technology transfer.

The approach adopted by the Subcommittee was to hold three weeks of hearings in May 1976, and to invite a wide number of persons to submit written statements for the record. In both instances, participants were selected to assure a thorough discussion of the issues referred to earlier. Their insights and recommendations were then analyzed to help form the Subcommittee findings and recommendations. The results of these activities are published in three volumes: (1) the transcript of the hearings, (2) the compilation of submitted papers, and (3) the Subcommittee Report.

CONSIDERATION OF PREDECESSOR REPORTS ON CIVIL AVIATION RESEARCH AND DEVELOPMENT

In the past 30 years various entities such as Executive Branch Agencies, Congress and specially constituted ad hoc organizations such as the Aviation Advisory Commission have concluded approximately two dozen studies and have prepared reports dealing with civil aviation research and development and government policy concerning the advancement of aviation progress in the United States. Among the better known are:

President's Air Policy Commission (PAPC)—The Finletter Report, 1947
Congressional Aviation Policy Board—Brewster Report, 1948
President's Airport Commission—The Doolittle Report, 1952
Aviation Facilities Studies Group—The Harding Report, 1955
The Curtis Report, 1957
Project Horizon, 1961
Civil Aviation Research and Development Study, 1968
Civil Aviation Research and Development Policy Study (CARD Study), 1971
R&D Contributions to Aviation Progress (RADCAP), 1972
Aviation Advisory Commission (AAC), 1973
EPA Report to Congress on Aircraft/Airport Noise, 1973

Among the more significant of the recent studies of civil aviation research and development conducted by the Executive Branch are the following:

A. Civil Aviation Research and Development Study.—This study was conducted by the Aeronautics and Space Engineering Board (ASEB) of the National Academy of Engineering in 1968. The ASEB had been established in May, 1967, to advise NASA and other agencies. Following consultation with NASA, DOT, FAA, The President's Science Advisor, interested committees of Congress and the National Aeronautics and Space Council (NASC), the ASEB selected as its first study, "An Assessment of Federal Government Involvement in Civil Aviation Research and Development." The major conclusions were:

> (a) The three most critical factors limiting the growth of civil aviation were (1) airport and support facilities; (2) noise; and (3) air traffic control, in that order.
>
> (b) It was necessary for federal aeronautical research and development to be much more closely coordinated: ". . . knitting together more tightly the civil aviation research and development activities of the Department of Transportation, its major operating unit, the Federal Aviation Administration, and the National Aeronautics and Space Administration, and especially dividing their responsibilities according to capability. The DOT should provide the leadership in con-

> ducting systems studies to identify, analyze, and rank civil aviation goals as well as the research and development needed to attain these goals; NASA should be responsible for research and development in all the areas of importance to civil aeronautics; the FAA should, in addition to operating the airways network, be responsible for the systems testing of the resulting operational concepts and hardware.

The ASEB study did not address the specific nature of coordination mechanisms that were needed.

B. The Civil Aviation Research and Development Policy Study (CARD Study), 1971.—Undertaken jointly by DOT and NASA at the request of Congress, the CARD's study's point of departure was the ASEB study. In addition, to DOT and NASA as the co-sponsors, DOD, the CAB, the Departments of State, Justice and Commerce, the ICC, the NASC, the Export-Import Bank and the NTSB each participated.

The purpose of the CARD study was to examine all the factors affecting the future of civil aviation. Despite the specific recommendation for improved coordination among Federal agencies having responsibility for aviation, through the NASC, the NASC was subsequently terminated. The NASC had been identified in the CARD Study as the "focal point for the evolution of national policy related to civil aviation."

The chief mechanism for monitoring progress toward CARD Study and other Civil Aviation goals has been Congress which conducted extensive hearings resulting in broadly endorsing the CARD Study recommendations.

C. R&D Contributions to Aviation Progress (RADCAP)—1972.—RADCAP was concerned primarily with the commonality between military and civil aviation development programs and the continued potential for fallout to the civil sector.

RADCAP, like CARD, was the result of Congressional inquiry regarding the degree of contribution of military aeronautical R&D to civil aviation. RADCAP focus was on the application of existing technology rather than the institutional framework under which the R&D was performed or implemented. However, RADCAP strongly endorsed the findings of the CARD Study.

D. Aviation Advisory Commission (AAC)—1973.—Congress, directed via the Airport and Airway Development Act of 1970 (P.L. 91–258), the formation of a national commission to determine the requirements for a long-term optimal national aviation system.

After the two-year study the Commission proposed actions through 1985 to be periodically updated by a National Aviation Plan each succeeding 10 years.

The AAC also strongly endorsed the recommendation of the CARD Study for interagency coordination of civil aviation activities through the NASC. Unfortunately, following submittal of the ACC Report to Congress in January 1973, the NASC was abolished by Executive Order the following July.

In addition to the three relatively recent Executive Branch studies described above, two others were of potential importance for the future of civil aviation. These are contained in the report of the

President's Airport Commission "The Airport and Its Neighbors" submitted to President Truman May 16, 1952 and the timely NASA study "Outlook for Aeronautics" published March, 1976.

PRESIDENT'S AIRPORT COMMISSION

The President's Airport Commission was established because of what was considered in 1952 to be a crisis situation arising in the development and operation of airports.

In its report, the Commission chaired by James H. Doolittle (other members were Prof. Jerome C. Hunsaker of MIT and Mr. Charles F. Horne, CAA Administrator), foresaw emerging airport problems—including noise—and recommended immediate action on a number of specific measures some of which are currently under consideration by the FAA/DOT, having been proposed over the last two years by EPA.

Unfortunately, the Commission did not address the institutional changes which would have been necessary to implement the "Doolittle Commission" recommendations. While the President asked the Air Coordinating Committee (ACC) to make suggestions for implementing recommendations of the report, no recommendations were made. Note: It appears the ACC (1945–1960) was ineffective on major issues because of its inability to obtain the unanimity upon which its decisions were to be based. Again, there was no top level decisionmaking authority for civil aviation.

A major proposal of the Doolittle Commission was the certification of airports. It was not until 1970 that airport certification was mandated by law (P.L. 91–258) although such authority was available as early as 1958.

The Commission foresaw the aircraft noise problem—over six years before the first jet flew in commercial service—and recommended preventive meaures to avoid the problem. None of these measures were adopted even after noise began to seriously impact airport/airlines operations as jet transports came into wide spread use.

NASA "OUTLOOK FOR AERONAUTICS"

The Study "Outlook for Aeronautics" was conducted on the initiative of NASA Administrator James C. Fletcher because of his concern for the continued "uncertainty in the aeronautical community." According to Dr. Fletcher,

> This Study presents a balance between the cautious view now prevalent and a more optimistic picture of certain important potential developments. It also provides a glimpse at considerably more visionary possibilities in the farther future.

Of course, NASA cannot be expected to deal with the questions of organizational adequacy which are at the center of civil aviation problems. Such basic questions Congress must address and the time may be growing short. The Subcommittee commends NASA's report "Outlook for Aeronautics" to all who are interested in the future of aviation.

Of the thirty or so predecessor reports dealing with civil aviation research and development, the two considered most relevant today are reports by this Subcommittee's predecessor in 1970 "Issues and Directions for Aeronautical Research and Development" (House Rept. 91–932, March 23, 1970) and in 1972, "Civil Aviation and Development: Policies, Programs and Problems" (House Rept. 92–1423, Sept., 1972). These reports resulted from extensive hearings which considered the findings and responses to the recommendations of the two CARD studies.

In 1970 and 1972, as today, there was deep concern that the U.S. civil aviation industry was in a period of great difficulty. In his letter of transmittal of the report to Committee Chairman George P. Miller, dated Sept. 11, 1972, Subcommittee Chairman Ken Hechler expressed the concern of the entire membership when he stated:

> There is little doubt that the civil aviation industry continues to be a vital segment of the U.S. economy. However, no such continuing organization or policy analysis by the National Aeronautics and Space Council has occurred. The fact that the NASC was disestablished in 1973 and was not replaced by a comparable coordinating organization has not altered the validity of the finding that U.S. civil aviation policy undergo continuous analysis and coordinating direction. Unfortunately, FAA/DOT has not fulfilled this function although fully authorized and constituted to do so since 1967.

Because of their relevance today, the following verbatim listing of the fifteen (15) recommendations of the 1972 report is provided:

> 1. The Civil Aviation Research and Development Policy Study Report (CARD Study) is an outstanding achievement. However, this type of policy analysis should be done on a continuing basis. The Subcommittee urges the National Aeronautics and Space Council to take the lead in establishing a continuing organization staffed by NASA, DOT and other appropriate organizations.
> 2. On a high priority basis there must be established a national aeronautics and aviation policy—with particular emphasis on aeronautical research and development.
> 3. The budget levels for civil aeronautical research and development—are still at relatively low levels while the broad array of aviation problems is increasing. Substantial budget increases are required in a number of areas such as noise abatement, aviation safety, propulsion and general aviation.
> 4. There is increasing concern by the Subcommittee about the United States retaining its world leadership in civil aviation. Vigorous measures must be taken to ensure that we maintain this leadership position. This issue must be considered as part of a broad debate on aviation policy in relation to national priorities.
> 5. The pattern of Government—industry roles and relationships requires additional study and clarification. New mechanisms and cooperative arrangements—subject to the will of the Congress—should be proposed by the Administration.
> 6. There is an increasing trend for U.S. aerospace firms to enter into joint ventures with foreign firms and countries

apparently motivated primarily by the weakened financial condition of the aerospace and air transportation industries. The subcommittee strongly urges the Administration to analyze this trend in terms of overall U.S. foreign trade and international investment policy.

7. Substantial progress has been made in developing more effective working relationships between NASA, DOT and FAA. However, periodic penetrating evaluations of these working relationships should be made to insure that they remain effective.

8. Progress has been made in developing more cooperative relationships between NASA and the Department of Defense. However, the major thrust of the testimony was on what NASA is doing for DOD. The flow from DOD to NASA was given much less attention. The respective flaws should be analyzed to determine if greater use of joint offices and activities would be useful. The Subcommittee believes that the growing pattern of NASA–DOD–FAA joint offices and activities offers an excellent guide for NASA–DOD relationships.

9. Evidence concerning the divergence of military and civil aeronautical requirements and research and development remains inconclusive. Additional study is required before the issue may be properly evaluated. Criteria for measuring the flows must be developed. The National Aeronautical and Space Council should insure that such a study be undertaken.

10. Considerable progress is being made in a variety of ways to solve the many facets of aircraft noise abatement. However, more rapid progress can and should be made on the basis that solutions to the noise problem are key to further advances in civil aviation. The subcommittee therefore concurs in the CARD recommendation that noise abatement should be accorded highest priority. Additionally, the subcommittee strongly urges that the Administration put someone in charge of the many facets related to the retrofit of the existing air fleet. Also, expedited work should be undertaken which could lead to availability of substantially more quiet new engines by the late 1970's for use in the next generation of aircraft.

11. Establishment of requirements for civil aircraft of tomorrow must account for the interrelated and sometimes conflicting needs of the community, the air transportation customer, and the air line operator. Propulsion is a key factor in all of these needs, yet there has been a substantial decline in propulsion research and development during the past decade. A large array of propulsion and aircraft requirements have been identified for the future. However, the subcommittee concludes there has been a lack of energetic U.S. effort to move ahead on these requirements. Strong measures must be taken to provide the technological base for the new aircraft and engines by NASA, DOT, the Department of Defense and industry.

12. Greater work must be done by NASA and industry in attacking the air pollution problem related to aircraft engine emissions.

13. Much progress has been made on the short haul, high density aircraft program during the past two years, although many problems lie ahead. Much study remains to be done in market analysis, system implementation and social benefits for both high and low population density aircraft programs. The subcommittee strongly urges the establishment of national goals and a centralized office to work on all of the complex system elements.

14. An Office of General Aviation within NASA should be established.

15. Significantly more work can and should be done in dealing with aviation safety problems. Urgent attention should be devoted to the safety and crash survival aspects of aviation. New measures for carrying out more safety analysis must be devised and put into practice.

With few exceptions, the fifteen (15) findings, conclusions and recommendations of the 1972 report reproduced above are duplicated in the findings and recommendations of this report. An added finding of this report, not found in these predecessor reports, is the requirement for fuel conservation. These previous findings are reproduced to illustrate the fact that the health of the U.S. civil aviation industry has long been in jeopardy; and, that unless implementation of the majority of these recommendations occurs, U.S. leadership in aviation will irretrievably be lost.

It is clear that the aeronautical problems identified in the 1972 report and its predecessors persist today. If the leadership role in international civil aviation enjoyed by the U.S. today is to be maintained the time for study and indecision has passed and the time for action has arrived. A new national commitment to civil aviation development must be taken.

SUMMARY OF HEARINGS AND CONTRIBUTED PAPERS

THIS SECTION PRESENTS A SUMMARY OF THE TESTIMONY OF EACH WITNESS WHO APPEARED BEFORE THE SUBCOMMITTEE IN THE ORDER OF HIS APPEARANCE FOLLOWED BY A SUMMARY OF EACH SUBMITTED PAPER IN ALPHABETICAL ORDER BY AUTHOR. IN MOST CASES, THIS SUMMARY IS THE ABSTRACT THAT EACH CONTRIBUTOR INCLUDED. WHEN NO ABSTRACT WAS PROVIDED, A STAFF-PREPARED SUMMARY IS PRESENTED

Mr. William T. Coleman, Jr., Secretary of Transportation, opened the hearings on the "Future of Aviation" on an optimistic note.

> This is an "important" time for aviation. For the mid-70's is a transition period for the industry—both the air carriers and the aerospace manufacturers. It is a time of transition—I believe—to a new and productive period.

He then presented a picture of the present industry. He noted that while "the operational side of the air carrier industry" is booming, the financial picture is not as bright. He did, however, in looking into the future, "see the industry making a strong economic comeback in 1976." And beyond then, he "looks for a substantial period of economic growth, which should reestablish a trend of both traffic gains and profitability."

Mr. Coleman illustrated the importance of aviation to other areas of the economic system of this country:

> The U.S. air carrier industry has an $18 billion capital investment, generating $15 billion in revenues, and providing 300,000 jobs. If we add the U.S. aerospace industry, we could include another $14 billion in investment, $30 billion in revenue for 1975, and over 400,000 jobs.

Secretary Coleman then listed some of the advancements that have occurred in the recent past that have raised our industry to its position of preeminence.

He indicated that "timely investments in research and development by the government and industry, working together, have made these accomplishments possible." He then summarized the agencies involved in federal R&D aeronautics, and listed the lines of communication between these agencies.

Secretary Coleman then went into "the economic problems of the air carrier industry . . .", which he felt could be ". . . summed up in one phrase—its low profitability for the past eight years." Consequently:

> The air carrier industry is suffering more seriously than most from the capital formation problem that confronts all U.S. industry. The airlines are finding it difficult in the extreme to obtain the funds they need to re-equip—to replace their aging fleets. This of course has serious consequences, in turn, for the aerospace manufacturers.

He attributes this to "the expensive and, on the whole, repressive impact of outmoded government economic regulation." He added that "the resolution of the airlines' profitability and capital formation problems will be the remedy for many of the manufacturers' problems as well." ". . . The long term solution . . .", Mr. Coleman recommended, ". . . for the economic troubles of the air carrier industry is reform of the manner in which it is regulated economically."

With regard to the question of how R&D should be funded, Mr. Coleman said:

> I believe the basic role of the government is to create the proper climate for healthy private operations . . . On the other hand, the Department of Transportation may properly take a role in the long range R&D.

Dr. Aaron Gellman, President of Gellman Research Associates, Inc., discussed innovation as a many phased process which begins with basic research and is completed when innovative technology is available to the public. The segment of this process that is downstream from R&D, called the technology delivery system, consumes most of the resources required for innovation:

> Since the innovation process is completed only with the "delivery" of new products (or services) to the market place, it is most important that the structure of the technology delivery system be market-determined.
>
> In general, direct Federal support provided at the upstream or pure research/R&D phase of the process of innovation is most justifiable since, other things equal, the externalities are relatively greater there.

He added that because barriers to the process completion may arise as the technology delivery system nears the market place, "the barrier removal role of the Government is generally of a different character and no less critical than is the Government's role as a sponsor of pure research . . ."

Dr. Gellman stated that "one of the reasons it is rational to continue substantial public support for R&D in the field of aviation relates to the concept of comparative advantage between nations. Often "comparative advantage in competitive situations is most effectively obtained and held as a result of an underlying process that permits a different and superior product to be turned out." Therefore, "a substantial proportion of aviation R&D resources should be devoted to generating processes which will keep U.S. aviation products on the frontiers of technological possibility."

Dr. Gellman suggested that a new area to which Government R&D funds could be applied is the early identification of new market opportunities.

He indicated that existing U.S. antitrust policy delays the working of the technology delivery system because without cooperation among otherwise competitive producers, private capital most likely will be unavailable to support large-scale innovative R&D. "If a situation arises where the choice is between U.S. participation in multinational consortia and an all-U.S. cooperative venture. . . . I suspect the latter is the better solution to the problem."

He added that the U.S. needs accurate indicators which will reflect the effect of R&D on productivity growth, and suggested that "a modest amount of the resources devoted to R&D in the aviation and transportation areas" be devoted to the development of such indicators.

Dr. Gellman also addressed the topic of the effects of regulation on R&D, explaining that the three main categories, i.e., environmental, safety and economic, can be either barriers or catalysts or, in some caees, both simultaneously.

Economic regulation, he stated, has perhaps the least understood but most profound effect of all on technological innovation. Dr. Gellman suggested:

> It would be a substantial contribution to improving the innovative performance of such industries . . . were the Congress to take steps requiring explicit consideration of the effects of economic regulatory policies and decisions upon technological change and innovation in industries affected by such regulation.

He supported the introduction into the regulatory process of the concept of a "technology impact statement" which would analyze the implication of regulatory constraints on private sector R&D activities.

On the topic of R&D investment decisionmaking, Dr. Gellman made several points. "One overriding objective of R&D policy, technology policy or innovative policy," he said, "should be to preserve the conditions under which the private sector increasingly bears responsibility for R&D the further one gets from the conception or invention end of the innovative spectrum . . ."

". . . to the extent the public sector funds activities in support of the process of innovation at all, such support should be heavily concentrated in the high-risk areas such as basic research." He explained that in the aviation industry, further along in the R&D process, the private sector is more inclined to expend the funds required for process completion.

He suggested that barriers to aviation innnovation include the high costs of prototype construction and testing, and Government limits on exclusivity with respect to patents.

Dr. Gellman concluded his testimony by stressing that,

> Because specific objectives must necessarily change with the passage of time, it is essential that R&D policies and program objectives be examined periodically to assure, first, that the mix between speculative and goal-oriented research is appropriate and second, that the goals of the latter case reflect the requirements of aviation and society at large.

Mr. Frederick W. Bradley, Jr. Vice President of Citibank, discussed the economic future of the aviation industry. He began his testimony with a discussion of the history of the U.S. domestic airline industry since World War II and its effects on the status of the industry today.

Mr. Bradley explained the industry's present financial problems from an historical perspective.

> Historically, the most important source of funds for financing aircraft purchases by the airlines has been from internal cash generation . . . supplemented by commercial bank loans, long-term loans from institutional lenders, the sale of equity and convertible subordinate debentures in the public market, and leasing.

He noted that with the advent of innovative and costly technologies, the airline industry has experienced increasing financial pressures.

> . . . due to the present econmic health and uncertain future of the airline industry, the outlook for future financing is not encouraging. The causes of the

> situation: rapidly rising fuel cost, deteriorating traffic due to economy, escalating wage and other costs due to inflation, and over-capacity due to the delivery of aircraft ordered when the outlook was more optimistic, are well-known.

Mr. Bradley stressed that although there has been an increase in airline traffic, the operating costs continue to escalate. ". . . as we look to 1977 and beyond," he remarked, "it is difficult to see where fare reductions will enhance profitability or improve the ability of airlines to finance new aircraft acquisitions." He added that the possibility of regulatory reform legislation becoming law and the projections for resultant decreased fares and increased competition already have had a negative impact on recent airline financing.

Concerning future sources of airline financing, Mr. Bradley discussed the industry's increasing dependence on commercial banks for funding. Questioning the capability of the banking community to solely finance large-scale programs, he suggested that joint ventures between U.S. manufacturers and major European companies could provide additional sources of capital and an expanded market.

Mr. Bradley concluded his statement with a discussion of the future of civil aviation R&D.

> . . . due to the generally weak condition of most of the major U.S. carriers, the limited internally-generated R&D funds available to the manufacturers are being applied to reengineering and retooling existing aircraft, rather than to the extensive R&D and pre-production engineering required to put a new technology aircraft into production.

Mr. W. M. Magruder, Executive Vice President of Piedmont Aviation, presented a powerful and somewhat startling picture of what has happened to the industry.

He addressed "two issues: first, the industry viewpoint of our situation today, a little about how we got to this point and where I think we could be headed; and secondly, some economic and institutional issues related to how the U.S. Government can play a successful role in aviation R&D." Magruder recommended a strong "national goal" for aviation as part of the solution to the problems plaguing the industry.

He then recalled the major events of the past five years in the industry, pointing out the areas where our aeronautical strength is fading. Magruder next looked at the optimistic side of the situation:

> Air traffic is projected to grow at from 5 to 8% annually while most other passenger transportation modes will slacken or grow at less robust levels. The world-wide new air transport market through 1990 looks to be over $70 billion, or more than all the history of civil air transport to date.

He noted that "almost all of the industry's major problems are external to the industry . . . one which often signifies justification for federal assistance."

He then discussed what he thought the criteria for government support should be.

> When the welfare of all citizens of the U.S. is affected and no one segment of the society can provide the right type of service; . . . when institutional restrictions . . . result in a clear impediment and government action is required to reduce the friction or barriers; . . . when externalities occur which are beyond the individual firm's control; . . . it is the position of the government that a surplus in the balance of trade account is necessary now and for future years if the United States is to finance its aid program to other nations and to meet its world commitments without further increase in its short-term obligations to official foreigners . . .

Magruder reviewed the conclusions of the Research and Development Contributions to Aviation Progress (RADCAP) study:

> Government sponsorship, primarily military, has provided most of the significant technological advances that have been made in U.S. aviation.
>
> Early military application of technological advances in accomplishing the defense mission has provided the basis for this acceptance and use in civil aviation.
>
> The benefits occuring to civil aviation from the military sponsored development and production base, however, have decreased in both relevance and importance.

Magruder went on to explain how the accepted criteria for government support applies to aeronautics:

> Aerospace is probably the single largest contributor to the national defense.
>
> Almost all of the industry problems eminate from "externalities" which are beyond the individual firm's or even the total industry's control . . .
>
> For the past decade, the aerospace foreign sales have been the difference between a positive and a negative balance of trade.
>
> Aerospace is near the top as a U.S. industrial employer, over 700,000 in 1975 and a conservative multiplier in terms of jobs of 2.5, about 1.8 million total or indirect jobs.

Magruder continued with the recommendation that:

> We can improve upon these basic economic criteria without distorting market forces by using some or all of the criteria developed by Patrick Hagerty's Report to the President's Science Advisory Committee . . . exploratory research . . .; whenever a major beneficial social impact can be determined, and the private sector is fragmented; high risk, duration and size of investment exceeds private capability; anti-trust law or the regulatory characteristics of the industry prevent R&D; when international competitiveness in world trade is threatened.

Magruder's final point was "the primary need in the civil aerospace industry today is to 'get well' as quickly as possible within the present system. To do this will require some and maybe all of the following:

> Stop the present "deregulation fever" in Washington, D.C. and establish reform within the present 1958 Federal Aviation Act . . .
>
> Establish a trust fund (tax free and interest earning) based upon a ticket tax and to be used for new equipment acquisition and noise alleviation . . .
>
> Allow replacement costs, not original costs, as the basis for corporate income taxation in times of inflation.
>
> Provide for government procurement regulation to similarly recognize replacement costs in overhead costs and profit aims during government contracting.
>
> Extending the investment tax credit and allowing its use as a tax rebate during times of severe inflation and/or depressed earnings from externalities.
>
> Adopt no-fault insurance for operators and manufacturers in order to reduce risks, costs and still provide fair compensation.
>
> Reduce the current ticket tax, waybill tax and departure tax for the airport trust fund and stop efforts to penetrate this fund for reasons not originally intended.
>
> The provision of a focal point in the federal government for aviation.

He added: "Once the restoration of the basic health of the industry is assured, some new and innovative ideas can also be considered for this critical industry . . .

> Tax incentives to stimulate more and better R&D.
>
> Broad base incentives to provide for the use of IR&D funds on any problem of national interest, conduct experiments to determine means of stimulating industrial productivity, use matching grants to certain industrial associations as a means of stimulating research in certain areas, national prizes and awards to stimulate inventions and innovation.
>
> A civil air transport financial assistance fund to provide financial assistance to airframe/engine manufacturers for new civil ventures.

Dr. James C. Fletcher, Administrator, NASA, accompanied by Dr. Alan Lovelace, Associate Administrator for Aeronautics and Space Technology, and Dr. Leonard Roberts, Director of Aeronautics, Ames Research Center, summarized the basis of NASA's concern for the future of aviation. He explained that such concern led to the NASA study, "Outlook for Aeronautics."

Dr. Lovelace amplified this by presenting a list of some of the advances by technology over the past 20 years. He cautioned that:

> In some areas we must work harder now to achieve less dramatic gains then the early breakthroughs—but the impact of small gains in a large system can be as great as, or greater than, that of the larger gains in the smaller systems of the past.

Accordingly,

> Because of the apparent changes in the aeronautical development picture and the related problems cited by Dr. Fletcher, the Outlook for Aeronautics study was undertaken to provide not a plan for the future, but a background of understanding to serve as a basis for planning.

Dr. Leonard Roberts who was director of the "Outlook for Aeronautics 1980–2000" study presented a summary of its results for the Subcommittee. The purpose of the study was "to make some careful judgments regarding the future outlook for aeronautics, to consider the part that NASA should play in U.S. aviation, and to define the emphasis that should be given to its program of aeronautical research and development."

The primary conclusions of the Study are as follows:

> 1. Significant developments in civil aviation are most likely to be directed toward greater efficiency in long haul subsonic aircraft, toward greatly improved short haul aircraft, and toward economically viable supersonic transport aircraft. Significant developments in military aviation will probably include: very long-range and long-endurance subsonic aircraft, more effective short-range support and logistics capabilities, and more cost-effective defense systems combining aircraft and advanced weapons.
>
> 2. Two aeronautical developments that are critically important to U.S. leadership in aviation deserve to be highlighted. They are (1) quiet vertical take-off and landing, and (2) efficient flight at supersonic speeds. These two developments would revitalize air transportation and provide new capabilities in air defense and air mobility.
>
> 3. To permit future progress in aviation, and to realize the attendant benefits to the U.S. economy and defense, a new generation of aeronautical technology must be created within the next decade. NASA has an essential part to play in the creation of this technology. Its primary role is to provide a firm technical basis for future developments in civil and military aviation. New aeronautical facilities are required for NASA to fulfill this role.

Dr. Edgar Cortright, President, American Institute of Aeronautics and Astronautics (AIAA) summarized the results of a recent workshop conference on "The Technical Basis for a National Civil Aviation RT&D Policy." The purpose of the conference was to assist the agencies responsible for civil aviation policy by establishing the characteristics of the technology base needed to formulate such policy. The conference stressed the technology requirements for air transportation systems that might become operational by the year 2000. It attempted to identify, review and assess the various technological alternatives and trade-offs, but not to formulate policy.

In the area of aerodynamics and configurations, the major objective is to improve performance and fuel efficiency in a wide variety of applications.

In the area of structures and materials, composite materials offer the potential for substantial savings in aircraft first costs and in increased productivity.

In propulsion, technological effort is required in reduced fuel consumption, noise control, emissions control, advanced component and materials development, reduced maintenance and first costs, electronic controls and alternate fuel development.

In the area of air operations, the major technology dependent needs for the future are: automation, greater system reliability, improved airspace and airport utilization, better man-machine interfaces, optimization of aircraft for terminal operations and improvements in navigation and altimetry.

Four areas of ground operations technology were identified for increased attention: airport design, access to the airport, expanded airport capability and intermodal transportation system integration.

The final area was test facilities. The conference concluded that existing facilities are not adequate to support expected needs through the year 2000.

Dr. John McLucas, Administrator of the Federal Aviation Administration discussed the relationship between military and civil aviation R&D.

For almost half a century, he said, military demands have required a steadily growing R&D technology base which has fed and acted as a catalyst for civil aviation innovation. However, he noted that "the days of 'direct' transfers of technology and equipment (from the military) to the civil side, such as the B–52 and the Boeing 707 are largely gone." The reason: design objectives for the military and civil sector are no longer the same. "New military aircraft are being designed to fly faster and carry compact weapons . . . Today, our civil aircraft are expected to be efficient, quiet, clean, as well as safe." He added that because DOD and civil aviation R&D tend to follow parallel tracks, an ongoing process of technology transfer is required to bridge the gap. "This is an area," he stated, "where the FAA can play a vital role in the identification of technological innovations that can hopefully lead to productivity gains."

Dr. McLucas discussed technological innovations brought about by the FAA in coordination with DOD and NASA, as well as private industry. He acknowledged the FAA's responsibility as lead agency in determination of long-range R&D needs, and outlined the basic technology studies and research programs which are presently underway to achieve these goals.

Dr. McLucas continued to discuss the need for R. & D. undertaken by the Government to be carried through to the point where private industry can assume final responsibility for its translation into marketable products or services. He stressed that this should be a primary objective of NASA's R. & D. efforts.

Dr. McLucas emphasized the need for a central office or person charged not only with the coordination of efforts in the field of aeronautics, but also with the authority to make policy decisions. He added that although a coordinating committee now exists among the FAA, DOD and NASA, there should be a formal relationship and more active input on the part of the CAB. He acknowledged that "we have not done enough in the FAA at the high level to deal with CAB people on a counterpart basis."

The future of supersonic aircraft was also mentioned. Dr. McLucas suggested that "NASA . . . should maintain an active SST program essentially indefinitely until one comes into being." He noted that when problems related to fuel efficiency, environmental acceptability and economic viability have been overcome, "there will be a time when we will have acceptable SST designs and there will be enough of a market to justify making them." But, he added, the aviation industry must become more attractive to investors, before new developments in aviation technology, such as the SST, will be privately or publicly financed.

Dr. Sayre Stevens, Acting Director for Science and Technology, CIA, accompanied by George Shevlin, Analyst; Raymond Blood, Economist; and Donald Massey, Assistant Legislative Counsel, began his statement with a look at the European aviation industry in the past, present and future. He pointed out that "the Western Europeans . . . have at least four aircraft that are technically competitive with aircraft produced in the United States." He also noted that they "are working on a broad range of aircraft that go substantially beyond those on which the United States is working. There are clearly efforts under way abroad to improve the facilities for civil aviation R. & D."

Dr. Stevens mentioned international technology transfer; in particular the GE/SNECMA joint venture.

Another point was made that U.S. firms have problems in obtaining capital for R. & D. while Europeans rely on government subsidy of their R. & D. efforts. He suggested that "the multinational consortia will indeed provide a good basis for the R. & D. and everything that goes with it." With this increased competition, Dr. Stevens went on to say that "U.S. industry is going to have to rely on something more than just technical superiority in the years ahead."

Mr. J. E. Steiner, a vice president at Boeing, began his statement with the importance of aviation to the economy and life in general.

> During the last 20 years, a combination of technologically founded factors has produced an air transportation industry that has had and is having a profound effect on our communication and our civilization. In fact, it has been said that air transportation is now the second greatest single-contributor to the rate of economic growth, exceeded only by education. It has affected our methods of doing busines, our pursuit of recreation, and the development of our young people. It is gradually eroding isolationism so that no portion of this nation or of the world is very distant from the rest.

He discussed the transportation industry as a composite of five aspects—social values, economics, utility, technology, and political/regulatory, and noted that:

> At any particular time, these five areas of pressure and constraints must be in equilibrium. If an element, for example, fuel conservation, changes the value

of one of the areas, then a new equilibrium will result. Perhaps by viewing transportation systems in this manner we can organize our thoughts a little better and direct our research and technology with greater wisdom.

Mr. Steiner then pointed out that "Air transportation . . . is not a luxury. It is one of the pillars upon which our economic system is supported."

About 600,000 passengers a day are carried by our U.S. domestic airline carriers. Ten years from now we expect this to increase to a million passengers a day. It is estimated that such flying is now participated in by over half of the total U.S. population.

He went on to note "the importance of the commercial air transportation industry" as:

A major and essential factor in domestic and international commerce;
A major industrial development factor;
A major producer of technological spinoff;
Provides jobs (300,000 airline, at both origin and destination, all 50 states) (600,000 manufacturer, multiplier effect, large to small companies). In the balance of trade, average of $4.2B/year for at least 5 years and almost $6.0B in 1975.

Mr. Steiner mentioned that the U.S. air carrier industry has "the elements of world leadership: availability of huge government sponsored technology base; availability of large, competitive, and financially capable airline system; availability for capable, competitive commercial aircraft manufacturers; travelers response to transportation improvements."

He proceeded to discuss some of the factors that have changed the situation:

Greatly reduced government sponsored R. & D. applicable to commercial aircraft (1955–1970).

Steady reduction in percent of total commercial airplane market to U.S. airlines.

Consequent increase in foreign manufacturing ambition.

Financial inability of major U.S. airlines to start new airplane programs.

Mr. Steiner focused on another point:

In the last decade, there has been a steady reduction in the percent of total world commercial airplane sales which the U.S. airlines represented. Ten years ago, foreign sales represented about 25 percent or 30 percent of the market. Today they represent 80 percent of the market.

While this will not be permanent, the consequence of this current shift, of course, has been a gross change in the ambitions of foreign manufacturers. Aided by government subsidy, they have been gradually building up ambition to challenge the policies of American domination of the commercial airplane market.

The start of new U.S. programs has always depended upon the financial ability of the major U.S. carriers. Foreign programs have not relied on airline financial ability. Foreign commercial airplane programs have been started by and sustained with government subsidies.

Furthermore:

Our real dilemma started nine years ago in 1967, when the profit of the 11 trunk carriers began its steady decline. No business can operate very efficiently on a net profit as low as 5 percent of total revenue. Yet, in 1969, we watched our 11 trunk airlines, which had been, in fact, responsible for our world aircraft domination, fall below this level. Since 1970, they have never been above 2 or 3 percent.

With reduction in profit and cash generation comes a deferral of buying in terms of equipment.

In regard to government in R. & D.—

There has always been a place for government in the development of research and technology. Long lead time areas such as engines, materials and processes,

> have not been successfully developed without government funding. . . . Another area where government R. & D. Funding is obviously needed, is that wherein the government itself is involved in the operation. Typical of such areas are traffic control and air navigation.

Steiner went on to say:

> There have been no new U.S. commercial airplane programs started for about 8 years. We did start, some years ago, to re-apply government research back toward commercial objectives. Thus, there is a sizable accumulation of available but unused research and technology in the U.S. applicable to commercial aviation. It is noteworthy that the application of this technology, in a new or major derivative aircraft, would be very supportive of current U.S. national objectives,—such as fuel conservation, community noise reduction, overall efficiency in the air transportation system.
>
> The total need for development toward better commercial airplanes is vast. The fact that we have done relatively little for some years has placed us in a position where we, as a nation, have no significant advantage in technology over foreign competitors. Regaining our former technological lead may, in fact, be impossible. It certainly is no use to follow a policy of isolationism since a great share of the markets is in foreign areas, and such policy would, of course, exclude us from those markets and reduce American jobs. . . .

In closing, Mr. Steiner stated:

> I would like to summarize the relationship we have been discussing between national objectives and available technology. They are, in fact, completely harmonious.
>
> The results which can be attained through application of that technology are in keeping with our national objectives.
>
> There has been a fundamental constraint preventing the application of available technology.
>
> We must ameliorate that constraint if we are to attain our desired national objectives.

And finally,

> . . . the system is interdependent. None of the dominos will stand independently. If we wish to regain our former competitive posture, we must create the opportunity for the application of existing technology by realizing the importance of the first domino—the U.S. airline earnings. In addition, for the future, we must involve ourselves in massive, government-sponsored technological development.

Mr. Frank Borman, former astronaut, currently President and Chief Officer of Eastern Airlines, concentrated his testimony on how "R&D . . . relates to commercial aviation."

He noted that:

> The aviation industry—both the manufacturers and the airlines—is facing perhaps the most critical period in its history, and the action Congress takes can determine whether the nation will retain its preeminence in both air transportation and the World commercial aircraft market.

On the topic of federally funded R&D:

> Since research is the broadening of the base of knowledge and should be directed toward societal objectives, it is only natural that the primary sponsor should be the government.
>
> We would urge Congress to insure that NASA has sufficient funds to pursue a vigorous program in . . . major areas.

Mr. Borman went on to explain:

> While this country has no special claim to leadership in basic research, we are the acknowledged leader in the application of that research. We have always been dominant in the commercial aircraft market . . .

He then turned to a major problem in the industry:

> The U.S. airline industry today has an aging aircraft fleet, a large proportion of which is becoming obsolete . . . If we are to improve our fleet's efficiency and make our objectives more compatible with this country's energy and environmental objectives, we must begin now to implement a program for replacing our older aircraft . . . Such a program is also essential to maintain an aircraft manufacturing industry which is competitive in World markets.

Mr. Borman continued to point out the consequences of the U.S. airlines turning to foreign manufacturers for new airplanes:

> The immediate impact would be a loss of employment opportunities in this country and an adverse impact on our international trade balance.
>
> Therefore, Eastern is recommending a coordinated program by government and private industry to begin now a new aircraft program, both to meet the needs of our air transportation system and to maintain the viability of our aircraft manufacturing industry.

Mr. Borman pointed out that it is not his belief that the industry can be remedied with "traditional procurement methods."

Borman concluded with:

> We do not believe direct government involvement in aircraft development to be appropriate.
>
> However, if a new aircraft program is to be realized, we do need affirmative government action to restore investor confidence in the airlines and manufacturers and to provide our industries with access to new sources of capital. Eastern has advanced specific recommendations toward that end . . .
>
> The key to investor confidence is Congressional reaffirmation of the principles of the Federal Aviation Act, which charges the CAB, consistent with the public interest, with fostering sound economic conditions in air transportation. We urge Congress to promptly dispose of the Administration's ill-conceived Aviation Act of 1975.
>
> Because of the financial difficulties of the carriers and the manufacturers, they have neither the internal financial resources nor the access to the normal capital markets necessary to undertake a major new program.
>
> Amendment of the tax laws to provide prompt refunds of investment tax credits which cannot be used because of the lack of earnings.
>
> Authorization of government-guaranteed loans if necessary for the development and procurement of new aircraft.

Ms. Mimi Cutler. Director, Aviation Consumer Action Project, presented the consumer point of view on needs for aviation R. & D.

1. *Safety.*—The primary concern of every person who steps aboard an airplane is to reach his destination safely. In the past several years, serious safety problems have shown up in the design of some new aircraft resulting from inadequate consideration of the ability of passengers and crew in emergency situations. In the design of future aircraft, emergency exits and emergency systems should be easier to use and more dependable.

Today, the technology exists to prevent many airline accidents and reduce the injuries in those that do occur. Aviation policy must deal with implementation of safety advances by the FAA. For example, the FAA has delayed setting toxicity standards covering the synthetic materials in aircraft interiors which give off deadly toxic gases when heated or burned. Although the FAA issued ANPRM's in 1969 and 1975, it still has not taken final action. Aviation policy requires a reinvigorated FAA.

2. *Economic regulation.*—Economic regulation affects the cost and demand for air travel and thus the timing and type of new aircraft needed. When carriers acquire a new type of aircraft, they must consider the price of a ticket. If there isn't adequate demand at the present price, they must be willing and able to cut prices to fill the aircraft. The B–747 could have provided long distance mass transit if fares had been reduced to reflect the potential efficiency of the aircraft.

The future ability of carriers to acquire the next generation of aircraft is affected by the type of economic regulation. The present rigid CAB price and route regulation has resulted in scheduling competition, low load factors and excess aircraft. The carriers are heavily burdened with debt and future interest payments, which limits their ability to finance future aircraft acquisitions.

Legislation is now pending before the Congress which would inject a measure of free market competition into the airline industry. Aviation research and development policy must take a position on the type of economic regulation which would enable the airline industry to best serve the public in the future.

3. *Noise.*—Excessive aircraft noise is limiting airline services and the development of airports. The Federal Government has delayed a decision on retrofit of noisy older type aircraft. At the last minute before DOT Secretary Coleman's decision on retrofit, the ATA submitted a plan recommending a $2.9 billion passenger tax for replacement of only B707/DC–8 aircraft over a 10-year period. In short, the ATA plan offers little prompt relief at an extraordinarily high cost.

Dr. Gus Weiss, White House Council on International Economic Policy, worked with the GE/SNECMA joint venture arrangements and has a special interest in the international transfer of U.S. technology. When asked about the possibility of two U.S. firms attempting this type of venture, he suggested that a combination of the existing anti-trust laws and the competitive nature of the industry would preclude it. To the suggestion of altering our anti-trust laws to enable U.S. plus U.S. ventures, Dr. Weiss' reply was negative:

> I think our firms are sufficiently strong that they can hold their own in the world market, assuming the R&D is supported, and to assume they cannot hold their own, and change the anti-trust laws, I think that would reduce the competition, and probably some of the incentive for quality work, and would probably hurt.

Looking at the benefits from foreign consortia, he listed the availability of foreign capital, the "access to foreign markets," and on a smaller scale, "our acquisition of some foreign technology."

Relative to governmental subsidy, it was brought up that foreign governments actively support their aerospace industries. In the U.S., "we used to get that (support from our Government), by virtue of the translation of what was developed for military purposes, into commercial aviation." He noted that this had changed, possibly because "military needs are diverging a bit from . . . commercial . . ."

A major topic of discussion that followed was that of the terms of the technological transfer. Many concerns were raised as to the possible loss of our top secrets as a result of this type of U.S. plus foreign venture. Dr. Weiss explained that our technology was safe.

Mr. Jack Hope, General Manager, CFM Program Department, representing the General Electric Company's aircraft engine group, began his statement with a brief look at where aviation has come from:

> We find ourselves today at a crossroads of sorts. We come from a past of preeminence of US aerospace products . . . We face a less sure future . . . and international markets are as attractive (if not more attractive) as our domestic demand, where the pace of technology is slowed and new requirements of ecologic compatibility and controlling cost of ownership vie with faster, bigger, better as design criteria and . . . where the assured support of R&D—from both the US government and from a strong private sector—is becoming less sure each day.

He went on to note factors leading to current U.S. preeminence:

> A significant point has been the "consistent" US government support of R&D directed in the first instance to military aviation equipment, applicable with private capital addition, to civil use.
>
> Thus, over the past 3 decades, the US has been "the" force in civil aviation . . . This has been a trade balance mainstay and resulted in many thousands of US jobs. The situation will not continue thus without conscious effort by the US government/industry teams.

GE discussed the advantages of joint ventures with foreign companies:

> Dictated equipment development and purchase.
>
> Taxes as a basis of capital formation for both manufacturer and airline.
>
> Creation of consortia—either intracountry or inter-region—to both develop and exploit new equipment.
>
> An environment of *consistent* government support which, over the long term, will nurture the industry much as has occurred in the United State over the past 30–40 years.
>
> Pooling of financial risk via joint ventures . . . is nearly unworkable among US firms for legal and competitive reasons. Joint ventures with offshore firms and governments are increasingly available and attractive offering reduced capital burden on each, complementary expertise, complementary market access.

GE went on to quote a Department of Commerce study:

> The United States is perhaps the only advanced nation in the free world which has not undertaken national programs to stimulate technology development in the civilian sector . . . The study also notes that other governments not only fund industrial research but also provide tax incentives, interest free loans and grants to stimulate the development and world wide marketing of innovative products.

The GE recommendation was:

> Revitalization of civilian research and development merits incentives not unlike those recommended for improving capital formation in the United States;
>
> Stimulation of R. & D. offers the opportunity for a redirection of government spending toward more productive ends;
>
> Greater industry-government cooperation is needed most in those high technology sectors where the scale and uncertainty of development costs, and the long time cycles required before these costs can be recovered make it difficult for individual companies alone to finance the essential R. & D.

Dr. Malcolm Currie, Director of Defense Research and Engineering, discussed the potential for future civil benefit from military expenditures in aviation R. & D.

Dr. Currie estimated "that approximately $300 million, roughly 15 percent of our current annual aircraft R. & D. budget, has direct applicability to civil needs." Within this amount are included "significant proportions of our basic research, exploratory, advanced and engineering development categories" but not development of purely military systems. Yet "because the engineering development of these systems is performed by the same companies that form the base for our civil industry, the technical advances transfer directly into the industry knowledge bank for future civil applications."

Dr. Currie described the important role that air transport plays in defense, referring to such future aircraft as the Advanced Medium STOL Transport and the Advanced Tanker Cargo Aircraft.

The need for upgraded test facilities and research aircraft was stressed as a common military and civil need.

Some of the areas where future civil and military technology needs are parallel are large logistics aircraft, V/STOL aircraft, helicopters and navigation systems. Areas where the needs diverge include: increased maneuverability, remotely piloted vehicles, and nap-of-the earth flying.

Dr. Currie highlighted some of the significant concepts which will eventually impact commercial and general aviation: fly-by-wire control systems, fiber optics technology, advancing blade rotor systems, the Advanced Turbine Engine Gas Generator, variable cycle engine, composite structures and engine components, and NAVSTAR.

With regard to enhancing the civil fall-out, Dr. Currie said,

> The major commercial airframe builders and propulsion companies participate in our contracted military technology programs. There is no better way to achieve transfer.

Mr. Karl G. Harr, Jr., President, Aerospace Industry Association of America, Inc. speculated that—

> . . . in the near term, there are three highly visible impediments to optimal development of aviation in the transportation system:
>
> *Poor financial health of the airlines.* Low profitability, inadequate depreciation schedules and concentration on environmentally related design and operating changes have reduced airline resources and have virtually shut off external financing. Airlines themselves are reluctant to commit themselves to new programs due to uncertainties raised by deregulation debate. Therefore, the support is simply not there for the development and production of aircraft exhibiting lower fuel consumption, reduced noise and emission, lower operating costs and improved safety and reliability.
>
> *Capital formation problems of the transport aircraft manufacturers.* All industry sectors, but particularly aerospace, are feeling the capital pinch. For reasons discussed, the four traditional ways of raising capital (depreciation, reinvested profits, debt, and new equity) are severely curtailed for the aerospace industry.
>
> *Foreign competition.* While the American aerospace industry has been remarkably successful in marketing its products overseas, growing European and Russian industries are presenting a challenge. Such nontariff barriers as directed procurement and offsets are making it increasingly difficult to compete and joint ventures are multiplying as a result.
>
> In the long range one factor, neglect of aviation R. & D., presents the greatest threat to the industry.

Aviation research and development. Cooperative arrangements must be worked out between industry and Government and it is suggested that NASA be the focal point, developing and maintaining special facilities and sponsoring research.

General Clifton Von Kann, Senior Vice President of Operations and Airports of the Air Transport Association of America, stressed in his testimony the importance of a strong aviation industry, and the role of the Federal government in maintaining U.S. preeminence in aeronautics. He described the financial crisis confronting the industry as self-perpetuating, pointing out that economic problems discourage new sources of financing.

General Von Kann focused his testimony on the role of the Federal government. "In considering the role for the government in R&D and in assuring the best possible flow of technology from research to implementation, it is important for the government to help create an environment in which airlines can prosper enough to buy new aircraft and new technology." Specifically, he outlined the following responsibilities which the government should assume regarding aviation.

> The role of the government should be to:
> Fund adequate research and development;
> Provide incentive to exploit the research and technology;
> Help create a financial and tax environment in which aircraft companies, by themselves or in sensible consortia, can produce the new products; and
> Help airlines to achieve the financial strength and stability necessary for modernization procurement.

Excessive government intervention could have a deleterious effect, he added, because the industry's health depends greatly on competition and close buyer-seller interplay. Thus, he suggested that "prototype development should not be undertaken by the government, but left to private industry and the marketplace."

General Von Kann went on to discuss the need for a focal point in government "to assure that a policy of U.S. aviation preeminence is carried out." He suggested that "the most simple and direct course would be to strengthen and augment the role of the FAA Administrator and to charge him with the responsibility to pursue a coherent policy of the United States aeronautical preeminence."

Resources and priorities for aeronautical R&D were discussed. General Von Kann pointed out that Defense Department R&D "remains a critically important source of technology . . . It is important that we do even better in assuring technology transfer; I believe FAA should play an increased role, working with the military, with NASA, and with industry to assure that we extract maximum technology benefits from applicable military work."

General Von Kann reiterated the opinion expressed by other witnesses regarding the R&D carried out by NASA. NASA, he said, should carry its work "not only to the feasibility stage, but also to prove concepts and to carry them to the certificable level."

Mr. Russell Train, the Administrator of the Environmental Protection Agency, began his testimony with a look at today's aviation industry.

> Economic, energy and environmental constraints have had a debilitating effect on the growth of the aviation industry. The economic downturn has resulted in limited availability of investment capital which has inhibited the development, manufacture and procurement of new, modern, more efficient equipment to replace existing aircraft which, although reliable and safe, still reflect the technology of the 50's and early 60's. The investment in R&D which has produced the technology in production hardware has been significantly restrained.

He noted that while large numbers of the cleaner and quieter aircraft were expected to be introduced into the air carrier fleet, they have not been introduced in the amounts that were projected. "This means that the older aircraft, which do not reflect the benefits of subsequent noise and exhaust emission control developments, will remain in the operational inventory longer than anticipated."

Mr. Train then explained that: ". . . the best technological improvement is only as good as the speed with which it can be introduced into the fleet." He explained that "once a technology development program matures and is ready for implementation, there always seems to be another program 'on the horizon' which may yield more significant benefits. Therefore, we were asked to wait for this future benefit."

Mr. Train, in support of government assistance to the industry said:

> We believe that some measures are necessary to help preserve the capabilities represented by these major contributors to the economic well-being of the United States.

But he did not have any specific recommendations.

> On the subject of regulations, the airline industry is a regulated industry and has indicated, quite strongly, that they recommend a continuation of this policy. The industry stresses the benefits of regulations as providing safe and efficient air transportation, not to mention maintaining the stability of the existing industry structure. We believe certain regulatory actions are also required to protect the people who are impacted by unnecessary pollutants developed as a by-product of this industry.

Mr. Train went on to explain how the imposition of guidelines on the industry would have a stabilizing effect.

> Today, the manufacturers are hesitant to commit to new engine and aircraft developments, not only because of current economic conditions, but also because of the confusion as to what environmental controls will be required of them in five years, for example, when they would be ready for production. The airlines are also hesitant to commit large amounts of capital, only to subsequently find out that the aircraft they procured in good faith may not be able to operate at certain airports or at times.

Train stated that the federal government should be responsible for establishing national aircraft environmental standards. With the federal R&D program, there could be a periodic review and possible reduction in such standards.

> In summary, we would enthusiastically support a National R&D policy or program that would improve the health and welfare of the aviation industry which at the same time is responsive to the health and welfare needs of the communities impacted by aviation noise and exhaust emissions.

In the questioning following his statement, some of the issues that Mr. Train touched on were the fact that EPA frequently submitted recommendations to the FAA which had never been acted upon. He seemed to feel that the alleviation of this situation might be helpful to the industry and the civilian sector.

Mr. Thomas Kauper, Assistant Attorney General, Department of Justice, focused on the antitrust considerations relevant to joint ventures in the aviation industry.

Basically, antitrust analysis of joint ventures requires a determination of whether there is a loss of competition caused by the combination of competing or potentially competing firms. Even if there are some anticompetitive effects, a joint venture may be allowed if it provides procompetitive benefits which are more substantial than its anticompetitive effects. In the aviation industry, many markets are quite concentrated, giving rise to antitrust concern about loss of competition from combination of the very few actual or potential suppliers of given products. On the other hand, the substantial business risks and technological challenges the industry faces are such that some innovations might not take place without joint ventures, and innovation is a vital aspect of the competitive process.

Mr. Kauper stated that he believes present antitrust law does not block reasonable joint ventures, and in fact promotes innovation and technological progress.

In response to a question in the Chairman's letter inviting Mr. Kauper to testify, Mr. Kauper said that the antitrust laws apply without discrimination to foreign firms within U.S. jurisdiction, just as they do to U.S. firms.

Mr. Edward Stimpson, President, General Aviation Manufacturers Association, recommended that Federal R&D programs meet one of the following criteria:

1. Solve problems of national public need, such as:
    - Fuel conservation.
    - Noise and emissions reductions.
2. Extend basic knowledge and state of the art, such as:
    - Basic aerodynamics.
    - Use of new materials.
3. Make Federal activities more efficient and improve safety, such as:
    - Weather information.
    - Air navigation and air traffic control.

We foresee a very good future for the general aviation industry. Federal research and development activities are an important element in assuring that the general aviation part of civil aviation continues to develop in an orderly fashion.

Government efforts should be directed toward the most productive and fruitful areas that are beyond the financial or technical capability or, in some cases, the responsibility, of the private sector. Efforts that merely apply the existing state of the art, i.e., building a low cost auto pilot or flight director, or working on technology that is already available, should not be undertaken. Resources are too limited to squander money on unnecessary projects.

For the last 20 years, the deliveries of new general aviation aircraft have grown at an annual, compounded growth rate of 6% in units and 14% in dollar volume. With the proper governmental and industry action taken today, we expect that this long term trend line will continue into the future.

In order to maintain this growth, we must not only have the Research and Development Program to meet the challenges of the future, but we must have public understanding to support the development of the entire aviation system. Without an informed understanding of the current contribution and complexities of civil aviation, both air carrier and general aviation, the future of aviation will be much more in doubt, and its potential to benefit mankind will not be achieved. Consequently, we are appreciative for these hearings and the actions of this Subcommittee, as they work toward the goal of better public understanding of aviation's contribution and challenges.

Dr. James Miller, Assistant Director for Government Operations and Research, Council on Wage and Price Stability, directed his testimony toward the subject of airline regulation.

> . . . I would like to comment on certain economic principles involving technology change and R&D, discuss how regulatory reform would affect the level and structure of the demand for aircraft, and finally, describe briefly two public policy approaches to establishing incentives for technological change in aircraft design.

He explained that while our free market system is usually a good allocator of resources, there are often "market imperfections" that are beyond its control. Such an instance is when R&D does not reach the market. In these cases, some type of intervention is needed.

> . . . the government might undertake certain R&D on its own . . . the government might subsidize R&D . . . the government may set performance standards for products and services that cause producers to invest more in R&D than they would have otherwise.

He went on to state:

> . . . a major dilemma for the R&D policy-maker is to know when, where, and how to intervene—but also, just as importantly, to know when not to intervene.

Dr. Miller then commented on the possible effect of the proposed Aviation Act of 1975 and the Air Transportation Act of 1976.

> . . . immediate and total deregulation would have little significant impact on the total demand for aircraft, at least in the short run. I would speculate, however that over the long run, regulatory reform would increase the demand for aircraft as the pressures of competition led to more efficient operations, lower operating costs, and even lower prices for air services.
>
> Regulatory reform would also, I believe, lead to the development of smaller, turbine powered aircraft, with a capacity of between 30 and 50 seats.

Miller then discussed the airlines' response to the fuel crisis. He noted that the airlines are turning to more fuel efficient aircraft and have adopted procedures that economize on fuel not because of governmental pressure to do so, but because of the financial pressure. In regard to the noise issue, the airlines are not seeking quieter aircraft on their own; the gradual switch to quieter planes is for the most part due to government pressure. Mr. Miller suggested that it might be more economical to retrofit only the newer, fuel efficient aircraft and get rid of the older, fuel inefficient aircraft or to locate them in less congested areas, where the noise level is not so high.

CONTRIBUTED PAPERS

Neil A. Armstrong, in his capacity as an advisory member of the Kenton County Airport Board serving the Greater Cincinnati area, summarized the R&D needs of civil aviation as follows:

> NASA and FAA should continue to further research and development in both retrofit and engine design that will assist in reducing to an acceptable level the nuisance of aircraft noise. Further studies should be undertaken to develop zoning and land use controls including specific recommendations on compatible uses outside airport boundaries.

The problem of inadequate pavement design to satisfy the needs of the jet era was discussed. It is imperative that improved techniques and concepts be developed to allow today's engineer to design an operational surface which will withstand the weight and frequency of current and future aircraft.

Mr. Armstrong expressed the need to expedite and improve the posture of aviation security, in light of the recent bombing at La Guardia Airport.

Mr. Armstrong suggested that—

> The FAA continue its research into: Aircraft fuel explosion prevention systems; Safe, non-toxic compartment interior materials; The practicality of an on-board internal fire suppression system; and the Design and construction of a small, quick reaction, all purpose CFR vehicle that can be purchased, maintained and operated at minimum cost.

In light of the number of accidents attributable to birds on air carriers, Mr. Armstrong urged the Federal Government to pursue methods to alleviate the danger.

Because of the problem of restricted visibility caused by fog, it was suggested that methods be sought—

> To minimize the impact of fog on aircraft operations to improve aviation safety, increase airport capacity and reduce inconvenience to the traveling public through development of operationally reliable fog dispersal system.
>
> A study should be undertaken to determine the technical, operational, and economic feasibility of new ground systems to significantly improve the recovery of heavy aircraft disabled or damaged at large airports.

Dr. Holt Ashley, professor of Aeronautics and Mechanical Engineering, Stanford University, began:

> Aviation is one of the two or three human activities where the highest demands are continually placed on applied science and technology. In the civil sector it will always provide essential transportation services for people and valuable goods—there is no superior mode to displace it in the manner that aircraft displaced ships and trains . . . (aviation) provides constructive sustenance for the national economy and promotes favorable trade balances.

He then stated that our aeronautical industry has been substantially supported by federally funded R&D and that it would be dangerous for that support to be cut back at this point.

Professor Ashley went into the areas supplying research which are experiencing "a painful erosion of 'constant dollar' support . . ." NASA's R&D budget is constantly being reduced. "The degrading effects of recent budgetary trends on NASA's in house strength must be reversed." A second area that concerned Professor Ashley was the dwindling number of students interested in aerospace engineering and related fields in our universities.

His suggestions to help rectify these trends were:

> First, the former NASA programs of academic fellowships and design traineeships should be revived.
>
> Second, the very effective NASA university research program should be encouraged . . .
>
> Third, . . . would be to permit NASA and DOD aviation R&D activities to increase their professional manpower . . .
>
> Finally, . . . research sponsoring offices in DOD have (which) developed the most sophisticated, successful and rewarding relationships with university science and engineering to be found anywhere . . . should be restored . . .

Professor Ashley concluded with:

> In summary, I am confident of a bright future for U.S. civil aviation. With an eye toward its longer term welfare, I have tried to outline a series of proposals for steps that might be taken by the Congress. As seen against the federal budget, they involve modest expenditures. Their payoffs are out of all proportion to their costs.

Mr. Harold Becker, Vice President and Treasurer, The Futures Group, reviewed in his paper the evolution of government participation in civil aviation R&D.

It summarized the de-emphasis of aviation R&D "which occurred with establishment of NASA and the dissolution of NACA. Potential DOD contributions to civil aviation also are discussed."

> The diversity of interests, especially federal, which influence civil aviation R&D policy is summarized and the current inability to formulate acceptable national R&D goals for civil aviation is also treated. Recommendations are made for a way to establish goals for civil aviation in terms of socioeconomic conditions in the United States and for establishing priorities for aviation R&D on the basis of those goals.
>
> Finally, the growing tendency for government and private sector employees to compete for federal R&D funds is described. Suggestions are made for minimizing this competition in order to foster increased motivation and creativity in the generation of technology to satisfy goals of civil aviation.

Mr. John G. Borger, Vice President and Chief Engineer, Pan American Airways, began his statement with a look at the recent history of transportation, especially noting aviation's present position of dominance.

> This combination of speed and competitive costs with safety, has resulted in the disappearance of passenger vessels and limited trains. This is the kind of transportation (air carrier) the passenger and shipper want.

Mr. Borger noted that "airlines could develop for the most part free of government controls—or interference—except with regard to routes, fares and safety."

With regard to R&D, Mr. Borger stated that since a close relationship between the builder and the operator is desirable, NASA's basic research is necessary, but—

> The manufacturers are better equipped to handle this phase (design and application of NASA R&D) because they are more familiar with manufacturing requirements and customers' desires, and they must bear the ultimate designers' responsibility.

On the subject of the financial crisis of the industry, Mr. Borger followed the same line of thought of many other witnesses. Due to inflation, there is more difficulty in borrowing the large amounts of capital needed to finance new airplane development and replacement of existing aircraft. He also noted that the major manufacturers are turning to foreign countries for financial assistance. He went on to note that there is a considerable amount of technology available that is not being utilized because the manufacturers cannot see a market.

> It therefore appears that the first prerequisite to renewed production of superior airplanes, and the overall health of the aircraft manufacturing industry, is restored financial health of the customer airlines, and confidence of the financial community of future health of the airlines.

Discussing the possibility of government support to the airline industry:

> If some way could be found to limit the manufacturers' total outflow of cash, it should be possible to maintain US leadership in transport airplanes, for the technical leadership is still well in hand, although vulnerable. Perhaps the government could provide financial support through guaranteed low interest loans, or some other means. But it is considered most important that the government

provide support—not control—of the program. . . Project control and responsibility must rest with seller and buyer, with the only government control that of airworthiness requirements.

In conclusion, Mr. Borger said:

. . . We have a good system; it works. If it is going through some rough spots, let's smooth them out, not abandon the system for another that we know hasn't worked as well.

Mr. John C. Brizendine, President, Douglas Aircraft Company, McDonnell Douglas Corporation, stated that air transportation remains a true growth industry and a major factor in the world's economy.

But disturbing trends are threatening the viability of the airline industry and its supporting manufacturing industry, and therefore threatening U.S. dominance in the world transport market.

Air transportation is vital to the U.S. economy. It provides 85 percent of the intermediate to long range common carrier movement, and we have no alternative system. It still is a bargain, with U.S. fares up only 35 percent over the past seven years, compared to rises of 86 percent in the Consumer Price Index and 100 percent in rail fares. Industry earnings, however, have not been commensurate with growth. The industry's ability to meet the demands of continuing growth and modernization is dependent upon the confidence of lenders and investors.

Proposed deregulation is a primary threat to this confidence. However, fare options and more liberal charter rules can serve both the airlines and the traveler while avoiding total disruption of the world's best air transportation system and the erosion of lender and investor confidence. We need to remove that threat to deregulation and continue to provide the best service at the lowest cost.

Technology can continue to provide the necessary increases in efficiency and productivity, but not if economic threats block airline modernization. Historically, the civil aircraft industry has transferred technology from DOD programs, with NASA assistance, to civil applications. Recently, however, DOD programs have had primarily tactical applications with little civil fallout, forcing both aircraft and engine manufacturers to seek risk-sharing foreign partners—with financial backing from their governments. NASA's budget is inadequate to replace the earlier DOD stimulus, and only a small fraction of that budget is applied to aeronautics. While IRAD has value, it offers little incentive to the commercial manufacturer.

To protect and enhance the U.S. industry's position, we recommend:

1. Establishment of a national policy recognizing the national economic value of the U.S. air transport system and the world market dominance by the U.S. civil air transport manufacturers.
2. Creation of a healthy U.S. airline industry through regulatory reform (as opposed to deregulation) and realistic fare management.
3. Recognition of public financial responsibility in the enforcement of environmental regulations, in terms of noise reduction and energy conservation approaches via modernization.
4. A new R. & D. policy providing direct NASA financial support of R. & D. leading to civil-applicable technological advancement.
5. Consideration of IRAD coverage for civil projects, with specific tax incentives for civil aerospace R. & D.

Dr. Robert H. Cannon, Jr., Chairman, Division of Engineering and Applied Science, California Institute of Technology, recounted the views he stated on R. & D. critical to the civil air transportation system when he left the Department of Transportation in 1974. He also commented on the Federal response to those issues.

Long-range R. & D. to satisfy potential requirements is required to maintain the continuing evolution of an effective air traffic control system. The present FAA R. & D. program addresses this problem.

Technical possibilities exist for improving aircraft fuel economy and NASA is pursuing these opportunities vigorously.

Probable requirements for cleaner subsonic and supersonic engines to protect the ozone layer were due from the Climactic Impact Assessment Program in 1974. Dr. Cannon focused on the results of that study in the remainder of this testimony.

The chief conclusions of CIAP were:

Preservation of the ozone layer is imperative.

Large scale commercial operations in the stratosphere require clear engine standards.

CIAP was a comprehensive technological assessment which reduced the uncertainties about the effects of high altitude flight from about 100 to the range of 3 to 10.

Two adverse environmental effects of stratospheric flight will require preventive measures for large fleet operations.

Low nitrogen oxide emissions will be required to avoid ozone depletion.

Lower sulfur content in fuels is required to avoid perturbation of the earth's heat balance by sulfate formation.

The CIAP Executive Summary recommends the following actions:

Development of international regulation of emissions and fuel characteristics.

Accelerated combustion research for low NO_x engines.

Use of low-sulfur fuels.

Development of a global monitoring system supported by continued research. Dr. Cannon concluded by mentioning that both NASA and FAA have taken important steps to implement these CIAP recommendations.

Mr. Richard E. Cohen, of the Bureau of International Commerce, Department of Commerce, began his statement with a look at the current position of the U.S. aerospace industry. He commented on the factors that are turning our manufacturers to foreign sources of capital and then suggested some possible solutions to this problem. Among these were: "direct government funding," "tax incentives," revision of "federal anti-trust laws," "investment tax credits," and the availability of "favorable financing". Regarding pure technology, he noted that the U.S. aerospace industry has placed "emphasis on research and development as an integral part of systems fabrication, rather than only as the first stage in production of an item." Concerning the balance of trade, the author noted that while the "aerospace industry is the nation's largest net exporter . . . the United States will not in the foreseeable future be able to rely on its areospace industry for increased contributions to the balance of trade position."

Mr. Cohen went on to note that while our civil aviation system is the best in the world, this has "been realized even though the U.S. Government provides no direct support to commercial aviation development, production and sales ventures except through the application of military and NASA research and development and Export-Import Bank loans and guarantees."

Mr. Cohen concluded his statement with:

> The magnitude of the industry's current problem in maintaining its world competitive position is that normal market forces cannot be relied upon to support its advantages in high technology. The cost of breaking new ground are higher than private companies or perhaps even private consortia are able to justify because the risks are so great. Other nations have recognized it in the area of research and development and have taken steps to assist aerospace and other technological developments. If the United States is to maintain traditional advantages in aerospace, it remains for the government to accept it as a proper sphere for support and action in concert with industry.

Mr. Harry Colwell, Vice President of Chase Manhattan Bank, N.A., presented an overview of the aviation industry today and projected demands for the future.

> Barring the collapse of the industry as the result of radical experimentation with the regulatory process, the airline industry should be able to regain a degree of financial health. . . . It is my opinion that this will occur in the early 1980's.

Discussing future aviation demands, Mr. Colwell stated:

> The greatest need is for planes that will not be so much faster than today's subsonic equipment but cheaper to fly and users of less petroleum, less air space with appreciably lower noise levels. . . . A new start-from-scratch cargo plane is also an obvious need, one suited to commercial freight.

The cost of developing each new type of aircraft is enormous, thus Mr. Colwell concluded that—

> New forms of cooperation and coordination between all parties involved will have to be developed if we are to proceed—and we have no choice but to proceed.

A "continued efficient transportation system" and strong national defense are keys to the nation's future prosperity, Mr. Colwell went on to say. Such is the justification for strong government support of the aviation industry, he noted.

> Continued basic research by NASA is a must, especially in the development of concepts and processes on the frontiers of technology which can be freely used by the manufacturers in their new designs. Also, some form of direct participation in the R. & D. of actual aircraft can be worked out.

Mr. Colwell added, however, that the market should continue to be the decisive influence on aircraft development. Therefore, he explained that—

> It is critical to keep in mind that only an economically healthy airline industry which can be able to attract the confidence of lenders and investors, who will hav to put up the purchase money, can in the end make the technological development worthwhile.

Mr. Andrew H. de Voursney, Group Vice President, Finance and Planning, United Air Lines, emphasized in his statement—

> The need for capital formation as perhaps the most pressing, unsolved problem now facing the airline industry. Analysis of the future demand and supply of investment capital indicates there is a significant threat of a shortage of capital which could have serious consequences for air transportation. The financial

> performance of the industry must be significantly improved in order for it to attract needed new capital which is far in excess of the industry's current capitalization. Based on relatively conservative assumptions as to obsolescence, growth and inflation, we estimate the investment needs of the industry will amount to $162 billion between 1978 and 2000 compared with current capitalization of $11.8 billion.
>
> United's forecast of future market growth is an integral part of its continuing long range planning activities. Strong favorable trend growth factors indicate continued market expansion. Air travel demand tends to rise and fall relative to the trend as the economy experiences cyclical swings. A significant change in the future will be the end of the long term decline in the "real" cost of air travel to the consumer; rising operating costs, a slowdown of technological progress and the need to restore adequate profit margins indicate that airline fares in the future must follow operating costs more closely. United's planning forecast predicts a growth rate for domestic scheduled passenger traffic of 5.4 percent per year from 1975 to 1981 and 3.2 percent per year from 1981 to 1990. We predict charter travel will grow more rapidly, averaging 25 percent per year to 1981 and 15 percent per year thereafter.
>
> In the near term, we expect no major change in the relatively low government priority assigned to air transportation R. & D. The most critical technical problem needing a rapid solution is the restriction on airport movement capacities due to increased aircraft separation to avoid wake vortices. A solution to this problem can save billions of dollars through avoiding the need for new or expanded airports. Development of new aircraft designs is closely related to restoration of airline financial health. The useful life of current generation equipment is now realistically viewed as about 20 years. A high long range R. & D. priority should be assigned to development of alternative aviation fuels.

Dr. George Eads, Executive Director of the National Commission on Supplies and Shortages, discussed what he perceives as a major gap—

> . . . between the economic concept of externalities as a justification for U.S. Government intervention in the process of developing commercial technology and the direction that, in practice, this intervention appears to be taking.

He argued that

> Unless the economics profession provides an operational concept of externalities for use by decisionmakers and monitors the application of that concept to specific situations, externalities may be discovered primarily whenever it is politically advantageous to do so.

Mr. Glen A. Gilbert, Principal of Glen A. Gilbert and Associates, compared projected air traffic growth with current system capacity noting the unlikelihood of significantly expanding existing CTOL airways and airport facilities. He also pointed out that a very few airports and airways in this country handle the majority of traffic.

Gilbert made the point that contrary to the general assumption that the introduction of wide bodied aircraft would alleviate system congestion, this has not occurred, primarily due to increased traffic separation required by the wake turbulence of heavy aircraft.

Mr. Gilbert's central theme was that while a few CTOL airways and airports are congested or approaching saturation, theoretical air space capacity remains relatively untapped. In addition, there are virtually unlimited landing areas available for RTOL/STOL/VTOL aircraft. He also urged the introduction of a new system of navigation both enroute and for precision final approach based on area navigation (RNAV) employing the new NAVSTAR satellite. While making a strong argument for expanding existing aviation system capacity through an outlined "action program", Gilbert's main thrust was the need for new technology air vehicles together with air navigation systems and landing areas optimized for their use in urban areas.

In reference to CARD, Aviation Advisory Commission, CAB Northwest Corridor and NASP reports, Gilbert emphasized we can no longer continue to rely upon CTOL air vehicles and landing areas if air transportation is to meet future public needs.

While several other witnesses have called for a strengthening of the U.S. air carriers' financial posture as prerequisite to initiating new aircraft development programs, Gilbert took a different approach. Undoubtedly, he felt that allowing the air carriers to dictate future air system design including vehicles would perpetuate existing problems. Instead, Gilbert would divert some DOT funding currently subsidizing passenger rail service to the development of new classes of aircraft and facilities optimized for their use.

Gilbert concluded that in order for aviation to develop adequately to serve public needs, the FAA must be removed from DOT and raised to a positon of authority commensurate with the role of aviation in our society.

Mr. Paul Gray, Graduate School of Business Administration, University of Southern California (Los Angeles), considered in his paper the technological and policy issues associated with the substitution of communications for transportation in intercity travel.

> It is shown that various forms of communication technology have become available within the last decade that permit substitution, including the development of intercity video conferencing networks and computer-connected conferences. It is concluded that current technology, if suitably exploited, can be made economical for many of the routine transactions that now require air travel.
>
> Experimental evidence. obtained abroad, indicates that many business travelers are willing to make such substitutions if services are available. Evidence has also been obtained that face-to-face contact is not generally required. Analyses are presented of the economic tradeoffs today as well as the energy requirements of air travel compared to communication.
>
> Policy implications involve considering the role of government in encouraging or discouraging substitution, the need for coordinating aviation and communications planning, and the need for determining in quantitative terms the extent of substitution to be anticipated over time.

Mr. J. C. Green, Manager of Operations Analysis for Sikorsky Aircraft, discussed the helicopter industry as it relates to the future of aviation. He projected that—

> Very large strides will be made in the next two decades, whereby the helicopter becomes a much larger element in the life of the U.S. citizen . . . In these circumstances, the role of the U.S. government in relation to R&D can be vital in assisting the helicopter industry successfully translate from adolescence to maturity.

Mr. Green noted that the large growth of helicopter utilization "will require expanded R. & D. in noise and pollution reduction and energy conservation."

He stressed the importance of the development of a "sophisticated low-cost navigation and air traffic control system" for use under all weather conditions, day and night. Several recommendations were also offered concerning trends for future R&D programs.

Mr. Green outlined his view of the government's role, particularly that of NASA and FAA, in supporting industry's R&D efforts. He mentioned that although the DOD has an ongoing helicopter R&D program, basic research carried out by NASA is required to address problems peculiar to civil air transportation. A national policy providing for the coordination of military and civil R&D is also needed, he added.

Mr. Green proceeded to discuss the status of foreign competition and its effects on the U.S. helicopter industry. The four major European helicopter manufacturers which are largely government supported, are planning future collaboration in such areas as design of new aircraft, development or modification of existing designs, and technology exchange. Thus, he noted—

> The advantages implicit in the broad-based U.S. market can be offset very quickly by a variety of low-cost aircraft with competitive performance features, produced under foreign government subsidy.

Mr. Malcolm Harned, President, Cessna Aircraft Company, stated that—

> During the past three decades General Aviation has experienced substantial and sustained growth. This has been due to major increases in the need for and the efficiency of this form of transportation. Similar growth and further improvement in usefulness is predicted for the remainder of this century.
>
> Realization of the expected growth and increased benefits from General Aviation is highly dependent on the environment provided by Federal Government. Economic, energy, regulatory, tax and trade policies will have major impact on the ability of all segments of the General Aviation community to utilize their extensive resources to enlarge and improve the contribution of General Aviation in the United States and for our foreign customers.
>
> The Federal Government aviation R&D policy will also have an impact on the development of General Aviation. In the past, NACA contributed much to the technical development of aviation, and today NASA has the capabilities to make a significant technical contribution. That contribution should be in research and basic technology development—not in applications engineering or prototype development. These activities require the synthesis and weighing of many considerations—technical, operational, manufacturing, marketing and economics. The General Aviation manufacturers have the background and perspective in these complex fields, and can do the applications engineering and product development job far more efficiently and effectively than a government agency, such as NASA.
>
> Areas in which NASA research could be of value in the continuing development of General Aviation are external noise, piston engine exhaust emissions, improved airfoils, composite structure, structural adhesives, structural loads determination, crash impact dynamics, and stall-spin research.
>
> An additional area of particular importance for government support is that of research and development within the aircraft industry itself where we strongly recommend some form of tax incentive to stimulate private investment in this area. This is particularly important because competitive foreign aircraft companies have their R&D almost entirely subsidized by their governments. In addition, to make NASA's basic technology research of value in maintaining our world leadership in aviation it is essential that some security system be created to restrict this technology to United States manufacturers for some reasonable period of time.

Willis M. Hawkins, Senior Advisor for Lockheed Aircraft Corporation, Burbank, Calif., stated that "the essential problem that faces the aircraft industry today is that the continuing depressed state of the transportation business, reflecting both the economy and the awkward history of rate setting and route allocation imposed on the airlines, has inhibited the demand for new transports" in spite of the fact that much of the technology exists.

> The problem of accelerating the utilization of technology will not be solved by demonstration in prototypes. The solution is to find some way for incorporating this technology into saleable articles and to make it possible for operators to purchase such equipment. In addition to the lack of capital, other inhibitions include the lack of ground facilities and community welcome necessary to bring new aircraft closer to the passengers which they could serve. In the face of such need, it may be useful to consider sponsorship of complete demonstration systems. The essential element of these suggestions is that no single prototype aircraft demonstration solves enough of the manufacturers' (or the airlines') problems to attract new capital.

In light of the weaknesses of the SST program, Mr. Hawkins suggested that—

> The Government probably will have to assume a sponsor role to utilize the technology which is now available—and I am further suggesting that such technology will benefit the public in a substantial way. I am also suggesting that such sponsorship will have to be extensive enough to carry the experiment into model operation, serving customers, before such a demonstration is convincing to the capital market.

Hawkins suggested bringing the benefits of new technology to the private pilot:

> New technology can be incorporated with less risk in the private airplane field because test failures are less expensive.
>
> It would be helpful to the private owner if some versions of automotive power plants could be certificated to aircraft use . . .

Hawkins suggested that:

> The government, in developing transportation policies, should seek some means of focusing its investments in the areas where maximum service is being rendered rather than on the basis of historic patterns of expenditure.

Dr. Klaus P. Heiss, President of Econ, Inc., began by summarizing the factors surrounding capital formation and productivity in terms of constituents of economic power in the United States (i.e. primary resources, labor and capital). He paid particular attention to the role of R. & D. and technology and its link to capital formation in the U.S. economy. He then reviewed the status and trend of R. & D. activity in the United States pointing out the stagnant funding situation from 1968 to 1974. He ascribed the lack of real growth in R. & D. to post-Apollo deemphasis and a dismantling of the Cold War aerospace apparatus. He concluded that the nation needs a commitment to R. &. D. spelled out in specific policy.

Dr. Heiss discussed the importance of R. & D. in terms of estimated public and private rates of return which demonstrate that it is an essential element of national economic growth. He particularly pointed out the correlation between R. & D. and productivity growth rate. He discussed the unemployment situation in the aerospace industry, where jobs are at the lowest level since 1960.

Dr. Heiss's main point was that the capital situation is worsened by "United States accounting procedures where depreciation costs are based on historical acquisition costs rather than current market prices." He noted that in the aerospace industry alone, depreciation costs will be understated by $4–$5 billion in the next decade.

He considered the NASA Fuel Conservative Aircraft R. & D. program as an example of a cost-benefits analysis and studies of the sensitivity of the benefits in fuel savings to parameters such as program delay, load factor, etc.

The final section of the statement was a proposal to adopt revised accounting procedures to include real depreciation costs to remove "strong disincentive" to any investment of funds in new technology equipment, machinery or other depreciable assets. It was suggested that this policy be applied to all asset-intensive enterprises.

Dr. Heiss included an exposition of West German Depreciation Cost Principles and Procedures which outlines alternate depreciation procedures where the "cost of acquisition or manufacture differs substantially from replacement cost, and this is not only a temporary development." The West German policy also allows for review of estimates of useful lives of assets so that "where depreciation changes are found to have been excessive or insufficient, they will be changed or credited, as appropriate to depreciation contingencies . . .".

Mr. Robert Horonjeff, Professor of Transportation Engineering, Institute of Transportation Studies, University of California (Berkeley) emphasized that continued government support for research and development is absolutely necessary to meet the future requirements of civil aviation.

> Currently the responsibility for carrying out R&D in the Federal Government is vested among several agencies (NASA, FAA, EPA, ERDA), each with its own budget. While these agencies have been doing a good job there is no effective mechanism to establish R&D priorities for civil air transportation considering the system as a whole, since no single agency has the responsibility for the entire system. To avoid disjointed R&D programs, overall coordination of activities is required to establish meaningful programs and their respective priorities. While some attempts have been made to coordinate programs among several agencies the results so far have not achieved a well balanced integrated civil aviation R&D program that takes into account the entire air transport system (door to door). What is needed is to identify those programs where payoffs are needed as quickly as possible and to separate them from programs of lesser urgency (i.e. reduction or elimination of wake vortices compared with propulsion systems for hypersonic flight). Once these programs are indentified priorities need to be established (i.e., does the Aerosat program or the STOL program have higher, lower, or equal priority with research on runway, taxiway, and apron pavement design?).
>
> A major focus of civil aviation R&D in terms of funding is on aircraft technology. R&D on airports and airport related problems, and the assessment of institutional and regulatory impacts on development of civil aviation, have been minimal. More funds are required for these endeavors. Likewise, studies to quantity short- and long-term financing problems in civil aviation and to identify, or devise, new funding mechanisms are desirable.
>
> The high cost of developing major pieces of hardware (i.e., aircraft propulsion systems) precludes manufacturers from undertaking potentially risky hardware development ventures, a situation which requires an examination of the required role of government in support of such ventures, as is being done in other countries.

David R. Israel, Technical Assistant to the Administrator of the Energy Research and Development Administration focused his testimony on energy and aviation.

U.S. Energy Consumption: Transportation uses 25 percent of total energy. Of this 25 percent, automobiles consume 52 percent; trucks consume 22 percent; and aircraft consume 10 percent.

The automobile is the primary ERDA target for transportation conservation.

Aircraft still consume enough (10%) to be of considerable interest.

Projected rates of growth for aviation indicate that by the year 2000, it could consume between 20 % to 33% of transportation's share of petroleum.

Aviation R&D conservation activities categories:

1. Improved efficiency of fuel conservation or increased productivity per unit of fuel.
    - (*a*) NASA Aircraft Energy Efficiency Program.
    - (*b*) DOD Aircraft Technology Programs.
    - (*c*) FAA Area Navigation Traffic Control Program. FAA Fuel Advisory Departure Procedure.
    - (*d*) Airline Policy to Increase Load Factors.
2. Alternate Energy Source Programs such as coal, shale, and tar-sand-derived syncrudes, hydrogen and various blends.
    - (*a*) NASA Study of hydrogen fuel for long-range subsonic aircraft.
    - (*b*) DOD/NASA Program to qualify syncrude fuels for aircraft.
    - (*c*) NASA Study on coal conversion to hydrogen methane and liquid fuels for aircraft.

ERDA is responsible for establishing an overall *National Plan* to determine energy conservation goals, to identify related agency and industry programs, and to encourage means to achieve conservation goals.

ERDA is effecting Memorandums of Understanding (MOU's) between ERDA/DOT, ERDA/NASA, and ERDA/DOD to provide cooperation and collaboration in achieving the desired goals.

Mr. Franklin W. Kolk, Vice President, Technological Development, American Airlines, began with a brief history of the industry.

> From the beginning airline operations have been marginal. It is safe to say that nothing but inherent optimism sustained the early group of carriers from the time of their founding until the mid 1930's, when the combination of available technology and proper sizing produced the DC–3 airplane—the first transport which earned any noticeable profits for any of the carriers. I believe these two basic factors, i.e. proper sizing and appropriate available technology, continued to create the growth of the American carriers from that day to the present . . .

He went on to explain that most of the technological innovations of the industry had come from the military establishment and more recently, from NASA. Mr. Kolk looked next at the situation of the industry today. He described it as having "run out of ideas."

> We cannot improve the effiicency by increasing the speed of aircraft or reducing block time. . . .
>
> Secondly, we cannot on a large scale, exploit increases in available range. . .
>
> Thirdly, the industry has sufficiently exploited unit size . . .
>
> Because of the relatively slower turnover in aircraft in service, the opportunity to introduce new fleet types becomes less and less and the temptation to

replace the existing aircraft with another of the same design family increases. All of this means that there is a body of technology available to us which we are not utilizing.

He then stated:

> . . . Without some *very* strong leadership in the Congress, it is possible that the airlines as we now know them will gradually disappear.

He listed what he thinks is necessary to remedy this situation:

> . . . An adequate and understanding approach to basic airline economics by the people and Congress of the United States.
>
> . . . Let us turn to some of the technical thrusts which might be of great assistance. The basic problem is to have airplanes which operate for less money per seat mile without basically increasing the size, speed, or range of the aircraft. This means an examination of where the money goes and an attempt by scientists to create technologies that reduce this money flow.

Mr. Kolk then discussed the position of military and civil R&D.

> . . . This has resulted in a situation where most of the money, most of the encouragement, and most of the support is associated with project oriented work . . . I make a strong plea for the encouragement of aeronautical technology in a pure sense to understand more about what we are doing and allow this understanding to create new ideas which we can bring to the surface and develop without hitching them to a *PROJECT* or a *BUZZWORD* or a *SLOGAN.*

Mr. John F. Leyden, President, Professional Air Traffic Controllers Organization (PATCO), stated that though the consensus of the aviation community believes that—

> The continued automation of air traffic control will greatly reduce the need for air traffic controllers in the future, PATCO does not agree. Since we believe that controllers will be needed, this paper addresses the issues facing the controller work force in the future.
>
> Specifically, we believe that controller training must be upgraded and broadened to keep up with the challenges of new technological advances. It is imperative that human factor studies begin in the field of air traffic control so as to forestall and predict the possibility of human error. Controller compensation, responsibility, and exposure to the job should be investigated if we are to extend the work life of the air traffic controller. Finally, PATCO believes that the air traffic control system should be reorganized into a quasi-public corportaion to best serve the needs of the nation and the aviation community.

Mr. Hans Mark, Director of the National Aeronautics and Space Administration's Ames Research Center, discussed two issues related to new aeronautical developments: a major growth area in technology and our image as a major nation in the world.

Dr. Mark stated that the major growth area in aeronautics in the next two decades will be in the field of Vertical Take-Off and Landing aircraft. Two reasons were given for this position. One is that VTOL Aircraft will be absolutely necessary if our Navy is to continue to be in a position to maintain control over sea lanes necessary for our trade, and will require a smaller, more flexible capability than the supercarriers. The second need for VTOL aircraft is to provide the Army with rapid mobility and decreased vulnerability in abitrarily located theaters of war.

Dr. Mark further argued the importance of foreign sales of aeronautical products as an important contribution to a positive balance of trade. In contrast to agricultural products, nuclear reactors, computer, etc., aeronautical products tend to be highly visible to the public. The fact that 85% of all commercial aircraft in the world today are of U.S. origin cannot be hidden by governments that do not want their people to know it.

Richard R. Nelson, of Yale University, for the most part quoted from his manuscript *The Moon and the Ghetto—An Appreciation of the Unbalanced Performance of the American Political Economy.* He presented the methods in which the government supported the SST and Breeder Reactor Programs as a general format for federal support. He covered areas such as "Federal Subsidy for Development of New Products for Production Sale by Private Industry to the General Public", the fact that there is little or no rationale behind federal criteria for support of R&D, and "The Problem of R&D Governance".

> Over the last decade much of discussion regarding public policy toward R&D for civil aviation has been concerned with the issue of whether public funds should be provided specifically for the design and development of equipment to be produced by private firms and sold in a basically private market . . .

He noted that some advocate a "more active civilian research and development policy", while he believes government subsidy and support to be necessary at times.

> . . . while the federal government often has supported research and development relevant to private sector activity, by and large, it has steered shy of supporting or undertaking research and development on a particular product or service whose normal channel of distribution would be through the market.
>
> . . . governmental R&D support has aimed to lay the basis for subsequent private development efforts, not to pre-empt those efforts.

He went on to note another major argument for federal support:

> . . . failure to exploit the technology . . . at the earliest possible moment would mean a loss of technological leadership which in turn would mean an irreversable loss of world commercial position.

Another point Dr. Nelson made was:

> The basic reason why private investment funds were not flowing into an accelerated development program cannot be ascribed to "externalities" but rather to the high cost and innate inefficiencies involved in rushing a technology. Common sense, history, and detailed analysis and tell us that there is a time cost trade off. Public subsidy can buy us time, but we pay for speed. The costs of hastened development must be weighed against the benefits of gaining an attractive technology sooner . . .

Another point that Nelson made is that "the governance of the provision of the goods and services with which R&D is connected, need close integration at the level of product or process development."

In regard to the fact that over 80% of the world's aviation fleet is American made, Nelson said that our country's dominant position is due to "not only the general technical virtuosity of U.S. commercial aircraft but also the good record of the American manufacturers in deciding when to embody technological advances in commercial products . . . In each case, the decision to produce a commercial design has been made by a private company risking its own funds."

Nelson suggested looking back to the NACA and AEC organization which had:

> A highly efficacious mix of governance of R&D, with applied research and development being relatively closely linked to the market, and basic research and exploratory development being given a much looser reign, and separate support.

Nelson concluded with the proposal that:

> Posing the problem in terms of the design of a semi-autonomous structure for certain kinds of R&D is a useful way to begin . . .

Mr. William Ottley, Executive Director of the National Pilot Association described the deficiencies in the FAA's R&D program, and offered recommendations for its future modification. In general criticism, he stated that the FAA has failed to:

> Determine requirements based on the total needs of the user community.
> Establish specific goals and identify long and short-term objectives.
> Delineate programs to achieve specific objectives.

He went on to mention the following inadequacies:

> 1. Uncoordinated duplication of programs within the government (particularly among DOT, FAA, NASA, NOAA and EPA).
> 2. Insufficient input from the user community into the R&D planning process.
> 3. Failure to consider the economic implications to the user of components of the FAA R&D program.
> 4. Failure "to recognize the intermodal aspects of air transportation in all its forms—scheduled/non-scheduled air transportation, commuter/third level carriers and general aviation."

Mr. Ottley made several recommendations which would make the FAA more responsive and better able to deal with the R. & D. needs of the aviation community. He emphasized that a national air transportation policy must be finalized, based on established goals and priorities.

Mr. Frank N. Piasecki, Piasecki Aircraft, summarized his statement by saying that—

> Our nation has great strength in the efficiency of our innovation process, the marketing of new products and the resulting growth of successful research ventures. One of the major sinews of this strength comes from the independent competitive nature of our civil research and development.
>
> Yet in recent years innovative growth has been reduced in aerospace particularly in vertical lift. Our technological leadership is waning from lack of new capital and from the decreasing number of independent organizations seeking innovation.
>
> This negative situation has come about for many reasons, including high taxes that do not leave sufficient surplus for reinvestment into innovative concept. Regulations on the sale and use of aircraft and operating procedures that favor fixed-wing transport aircraft add to the large financial investment required before income is received.
>
> Competition is unbalanced by the government permitting the larger production Aerospace companies to charge their "Independent Research and Development", and proposal and bid preparation costs, to government contracts, whereas the innovative small company just starting must pay for such costs out of its capital. Unsolicited proposals created by innovators find additional hurdles as they are limited in dollar value ($100,000), and by annual funding and budgeting requirements.
>
> Many procurement practices exist negative to innovation, including the separation of the idea from the innovator, long time delays in "evaluation" of a new concept, doing the research work inside the government instead of through the proposer, splitting the idea into parts to dissociate the originator, and deprecia-

tion of the innovator's patent position. Finally, if the new concept runs counter to the existing "plan" it is rejected as having "no existing requirement", whereas other systems continue in their production.

Private capital cannot make the necessary investment risk with a small company. SBA and FDA funds are available for such ventures but are restricted in their use and amounts. DOD approaches the innovation with a time scale that does not match the subsistance requirements of the innovator. Foreign competition developments proceed with their (and sometimes our own) government's assistance. What happens to the innovative concept? In one case it waited 16 years for recognition and used up 12 years of its patent life. What does the innovator do? His fate will be a mark of discouragement to those who follow and deduce, "Why innovate if the carrot is but an illusion?

Suggestions are offered for government action to improve the climate for small business attempts at innovation, including:

1. Guaranteed loans to small business repayable from the proceeds of innovative product development.
2. A portion of R & D contracts to be set aside for small business equal to the IR&D funds allowed by the government to be charged off to government contracts.
3. Increase the $100,000 limit on unsolicited proposals to $1 million.
4. Laws to limit government in-house work, in order to maximize the use of outside industry.
5. Laws to limit the use of "Non-Profit Think-Tanks" for evaluation and planning purposes (which is the job the government is supposed to do in-house). (Ref. 9)
6. Patent life to be extended to 25 years, or more.
7. No indemnification guarantees be issued by the government for patent infringement by its contractors.
8. Procurement requirements to be stated by functional performance and not in hardware terms, to permit greater use of innovation to assist in the solution of our national problems.

Mr. Paul Poberezny, President of the Experimental Aircraft Association, discussed the interests of those involved in personal flying which are related to aviation R. & D. He suggested that "government R. & D. efforts should be directed toward a future air traffic control system that is more flexible than the present Beacon System or the proposed DABS/IPC system." An ATC system, he said, should permit more direct routing between small communities. "The present ATC system . . . does not have the flexibility to handle random movements that are at the heart of personal flying."

Mr. Poberezny also discussed NASA's role in R. & D. "We believe NASA should have the responsibility for basic aeronautical research with the FAA confined to the application of that research . . . no overlapping of efforts."

Weather information dissemination is very important for personal flying. Mr. Poberezny discussed in his support for "a 24-hour television weather service on a discreet channel (probably a UHF channel) which would provide continuous pictorial weather information for all classes of users."

The FAA proposal for the development of a Beacon Collision Avoidance System which would require Mode C altitude reporting transponders would be an economic burden to small aircraft flyers, according to Mr. Poberezny. He emphasized the importance of a backup CAS system, and recommended the development of independent airborne collision system.

He concluded his statement by mentioning his support of the NASA program investigation modifications of aircraft designs to deal with the problem of Wake Vortex.

Simon Ramo, Vice Chairman of Board, and Chairman of Executive Committee of TRW, considered the problem of ensuring an adequate R&D base in private industry which must remain healthy to retain U.S. strength in aviation. He pointed out the need to recognize the following factors:

Since military and civilian aeronautics are closely related, extraordinary benefits are realizable through mutual exchange of information, facilities and expertise, and this should be encouraged.

The aircraft industry is complex and private companies must retain large permanent staffs and supporting equipment and facilities.

Funding instability impairs the health of the industry as evidenced in the past decade and the forecast for future funding levels is not attractive for corporate financing.

A stable quality aircraft industry requires a minimum of three companies[1] The nation today has several times this number and even the strongest are not utilizing their full potential.

The above considerations led to these recommendations:

The government should encourage an environment for mergers aiming for fewer but stronger companies, even if it requires legislation.

The government should ensure stable R&D funding by multiple year funding commitments to programs from the outset.

The government should continually evaluate the private sector to ensure that the three strong competitors remain healthy.

The government should provide a steady program of R&D support for specialized companies, such as component and subsystem concerns, separate from the large aircraft corporations.

Robert A. Richardson, Executive Director of Helicopter Association of America included a memo prepared by Boeing Vertol. Boeing Vertol believes the salient points to be:

> **Helicopter R&D will be primarily funded by the military for the foreseeable future.**
>
> **NASA will have a specific role to play, both with the military and by itself.**
>
> **NASA must more clearly define this role in civil helicopter development and should devote more of its resources to rotary wing R&D.**
>
> **Both NASA and DOD sponsored R&D should primarily be accomplished by R&D contracts with industry.**
>
> **DOT and NASA should conduct concept formulation studies to determine specific civil requirements.**

The memo also included the following points:

Military spin-offs in helicopter technology have been major contributors to the limited commercial market because of the high cost of R&D. However, the civil market has potentially great promise but with growth strongly dependent on cost, convenience and enhanced safety.

Civil helicopter market projections are:

General aviation—largest market because of small size and relatively low costs.

Industrial—Utility Tactical Transport Aircraft System (UTTAS) type will fund primary use in limited access areas.

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[1] Presumably this includes aircraft companies who manufacture strictly military airplanes as well as the three major companies who produce large commercial transports.

Short-haul (passenger carrying)—Greatest potential but future questionable because of strong dependence on reduced costs and development of integrated intermodal transportation system. The latter requires detailed concept formulation by DOT and NASA with industry.

DIRECTIONS IN HELICOPTER R&D

The Army sponsored UTTAS and Advanced Attack Helicopter (AAH) programs comprising $1 billion in R&D. The civil UTTAS version is appropriate for industrial use. The AAH has no direct civil application but the technology should transfer. The comfort factors of current helicopters must be improved for civil acceptance.

The memo also considers how civil helicopter R&D should be conducted. NASA has "piggybacked" on military technology despite recent large programs for Rotor Systems Research Aircraft (RSRA) and Tilt Rotor. The activity is still small compared to fixed wing development. It is recommended that NASA expand its basic R&T role in helicopter R&D while maintaining close coordination with DOD research.

The memo argues against a two company industry versus the present four companies on the basis that initiative would be stifled in a less competitive situation.

Mr. Richardson also enclosed a position paper from Detroit Diesel Allison Division of General Motors intended to be an "Industrial View."

The paper pointed out the decreasing impact of military fallout on civil aviation increasing business risk for development. U.S. supremacy in helicopter development must meet overseas challenges with government assistance.

Civil aviation goals should be established so that NASA aeronautical labs can fill the role of civil counterpart to the Aero Propulsion Lab. The paper further stated that NASA's charter must be expanded to allow development effort similar to military programs. It concluded by stating that NASA should increase its emphasis in developing an advanced technology base, particularly in propulsion.

Mr. John E. Robson, Chairman of the Civil Aeronautics Board described the role of the CAB in setting economic regulation for commercial air transportation and the relationship of that function to the R&D process. He pointed out that:

> The relationship between economic regulation and technological development is complex. Nevertheless, ascertaining this relationship would appear to be important in developing both regulatory and R&D policy.

Regulation affects competition which in turn affects the R&D process. The CAB believes that greater competition will be beneficial and will influence the development of specialized aircraft. Regulation may also affect the degree of concentration in the air carrier industry which could change the traditional pattern of large orders as the launching mechanism for new aircraft.

Mr. R. W. Rummel, Vice President, Technical Development, Trans World Airlines, made the following points in his prepared text:

The U.S. airline industry will be unable to sponsor advanced aircraft development programs until it is allowed and sustains a reasonable level of profitability.

The U.S. airplane manufacturers are now and will remain unable to launch new transport aircraft programs due to lack of airline customers.

U.S. aircraft production rates continue to fall. Some production lines are critically close to shutdown. Without new programs U.S. manufacturers will not be able to maintain effective design/production teams and facilities. These important national assets once lost are not easily reestablished.

The timely development of very energy efficient, ecologically acceptable and economic aircraft is clearly in the national interest. Although the essential technologies are well advanced, the U.S. production of such an aircraft is not apt to occur until the financial community's confidence in the airline industry is restored.

Concerning retrofit requiremets, we badly need both a more critical view of cost-benefit relationships and a recognition by the goverment that any requirement mandated in the public interest should be publicly financed.

The world's best aircraft have historically been produced in the U.S. by private ventures of the manufacturers working in close liaison with airline customers supported by a solid foundation of Federally sponsored technology development. This practice has no parallel in other countries. There is no reason to change the successful formula.

The European airplane industry supported by its government is developing new transport aircraft in furtherance of its ambition to capture a larger share of the world aircraft market. It has adequate technical and financial capability to do this. The potential adverse balance of trade impact on the U.S. is obvious.

The U.S. aviation industry is fighting to survive in a very complex environment and to regain public, regulatory, and legislative understanding of our need for responsible growth. Failure in this process could commit still another U.S. industrial asset to the international chopping block. Ours is the kind of country that invents the steamship, then presents its whole maritime industry to the other nations of the world and becomes dependent on them for our shipping.

Dr. Silverstein, Retired Director, Lewis Research Center, NASA, recounted the major contributions of military R&D and the National Advisory Committee for Aeronautics to civil aviation. He pointed to the continuous progress spurred on by military independence, R&D funding and most recently demonstrated in the 747, DC–10 and L–1011. Today's research points to clear directions for aircraft technology development which the U.S. must pursue to retain aircraft supremacy. Projected aviation growth indicates requirements will at least triple by 2000. A national policy for capturing this market includes strong participation by NASA, industry and the universities.

Recent development costs for new aircraft are so large relative to industrial capitalization that the companies may have to risk bankruptcy to embark on prototype development.

> It would appear that legislation may be required to establish some *new method* for creating future prototype and development aircraft in the large transport class that will *reduce this inordinate risk* by the participating contractors. For this purpose, it may be desirable to create by legislation a *corporation owned by a consortium of the principal aircraft manufacturers, the United States Government and the public.* The combined scientific, technical, administrative and manufacturing talents of all participants will be directed toward the creation and production of advanced transport aircraft. The corporation might be *modeled after* the Communication Satellite Corporation (*COMSAT*). The corporation would use the developmental and manufacturing talents of the existing aircraft industry on a competitive basis.

The timeliness of this action is necessary to retain our world leadership position to foreign builders.

> Competence in the construction of the Concorde aircraft has been demonstrated. Their choice of the Concorde for a combined effort was unfortunate. Their next effort may be on target.

Mr. Ronald Smelt, Vice President and Chief Scientist for the Lockheed Aircraft Corporation used a speech given by Najeeb Halaby, FAA Administrator in 1961 as a reference for his statement concerning future aviation goals and needs. He pointed out that the problems confronting the airline industries fifteen years ago are similar to those existing today, and have only grown more acute with time. He acknowledged that—

> In large part, (these problems) are associated with the nature of the process of introduction of any new technology. The R&D phase, currently receiving significant support from the U.S. Government through NASA, is only a small fraction of this total process; the larger part has been provided by the aircraft and airline industries at considerable financial risk. The unhappy financial consequences of this are such that it may be necessary, in future technical advances, for the Government to share the risk of development downstream of the R&D process itself.

Mr. Smelt made the following observations on the state-of-the-art of aeronautical R&D and prospects for the future of the aviation industry.

> New technology is front-loaded, requiring a short-term investment in anticipation of much larger long-term gains. The financial rules and regulations under which the aircraft industry and the airlines conduct their business are completely inadequate to handle the introduction of new technologies with these financial characteristics. The Committee could most profitably examine this problem by reviewing the two most probable candidates for technological advances in the near future. In order of priority these are (a) the fuel-conservative subsonic transport aircraft, and (b) the advanced supersonic transport.

Mr. Floyd Smith, International President, International Association of Machinists and Aerospace Workers began his statement:

> As a trade union representing over 250,000 workers in the aerospace and air transport industry, we are certainly concerned wth the outlook for these industries as well as the broader subject of a national transportation policy . . . I would like to respond . . . to the specific issue of R&D funding in the United States and its impact on the aviation industry.

Mr. Smith went on to give his explanation for the United States' economic preeminence in the world as having had as one of its main bases the "nation's leadership in technology. . . . But many share the deep concern of the technical community that the US technological lead is eroding."

Mr. Smith quoted a Department of Commerce study which says:

> The United States is perhaps the only advanced nation in the free world which has not undertaken national programs to stimulate technology development in the civilian sector.

He went on to note that—

> Government funded R&D in the US has declined from 1.9% of the GNP in 1965 to only 1.2% in 1974. In real dollars, this has meant a 16% decrease over the past decade, substantially weakening the creative government/industry/university partnership of the 1950's and 60's.
>
> One of the more direct challenges from abroad is in aerospace. An area of especially serious potential impact is the world civil aircraft market. Estimated world sales volume of airline transports is $150 billion in the 1970–1985 time frame and $200 billion or more by 1990. The US is currently supplying about 80% of the world market for civil aircraft, which the European nations combined account for only 16%. One important factor in traditional US dominance in this area has been the vastly greater US domestic market which is a basic foundation for longer production runs, hence lower unit costs. Another factor has been the US ability to provide high levels of developmental investment. A third has been the wide variety of aircraft types offered by us. . . . It is Europe in combine, rather than the US, which boasts the more extensive range of aircraft offerings for the future.
>
> One cannot understate the important role technology plays in maintaining the dynamic viability of the U.S. economy: its contribution to our international trade balance, its potential for increasing national productivity and economic growth, and its existing capacity to generate employment opportunities. It seems clear that existing policies and coordinating mechanisms are not recognizing or adjusting on a timely basis to the present adverse trends and that new direction and increased emphasis will be required to reverse them.
>
> The long lead times associated with R&D in moving from concept to practical application demand immediate policy attention to revising existing trends in the areas of challenge vital to US productivity, economic strength and world leadership position. The IAM recommends these elements to be included in any new national R&D policy:
>
> Establishment of an independent government financial organization such as a national technology bank . . .
>
> Examination of the nation's antitrust laws and their administration . . .
>
> Development of innovative government/industry relationships . . .
>
> Intensification of efforts to eliminate tariff and non-tariff trade barriers . . .
>
> Insuring that adequate financing at rates competitive with those offered by other nations is available for both civil and military exports . . .

In conclusion, Mr. Smith stated that—

> The IAM believes that: Revitalization of civilian research and development merits incentives not unlike those recommended for improving capital formation in the U.S.; stimulation of R&D offers the opportunity for a redirection of government spending toward productive ends; greater industry-government cooperation is needed most in those high-technology sectors where the scale and uncertainty of development costs, and the long time-cycles required before these costs can be recovered, make it difficult for individual companies alone to finance the essential R&D.

Dr. H. Guyford Stever, Director of the National Science Foundation and Science Advisor to the President, along with Dr. Dennis Schiffel and Dr. Alden Bean, Senior Science Policy Analysts, question the appropriate role of government in aeronautical research and development (R&D). To define that role the paper suggest that—

> It is necessary (1) to understand the institutional structure of the aviation industry, (2) to understand some characteristics of aeronautical R&D, (3) to identify aviation policy issues which may confront the Federal Government, and (4) to have some economic criteria or guidelines which apply to potential investments in an aeronautical R&D. Neither economic criteria alone nor general policy issues in isolation will provide adequate definition of the appropriate government role in aeronautical R&D.

The authors suggest that—

> Recent trends in military aeronautical R&D and in the commercial fortunes of aerospace manufacturers and airlines may portend a decreasing level of commercially oriented or commercially adaptable aeronautical research. Some potential policy issues are raised, relating to foreign competition, financing of R&D, and the market size/production volume characteristics of aircraft development and production, which may affect government's role in aeronautical R&D.

Mr. T. R. Stuelpnagel, Vice President and General Manager Hughes Helicopters, projected that the—

> Helicopter will make its next major contribution in improving the quality of life by helping solve the urban transportation problem. Small helicopters can be used to relieve urban growth by encouraging decentralization of new industry to the outer fringes of the urban area. Large helicopters of 10 to 12-passenger size can be used as commuter transports on a 10-minute departure schedule throughout an urban area to maintain efficient urban mobility for existing businesses to prevent the exodus of jobs and tax base.
>
> Helicopters are also contributing phenomenally to an average of 10% suppression of crime and a two to six times increase in apprehension of criminals for 1% to 3% of law enforcement budgets. This breakthrough needs more encouragement at the national level.
>
> A civil aviation policy is required to recognize the helicopter as a necessary urban transportation vehicle by initiation of demonstration transportation programs. Consideration should be given to a means of sharing the risk with industry in developing the required transport helicopters. Assistance is needed throughout the country in heliport development and regulations. Support is needed by NASA and other agencies in R&D funding to develop quieting, flight safety and public safety application technology.
>
> Two percent or $1 billion of the national public transportation budget will contribute 250,000 jobs per year to urban communities nationwide, plus $100 billion in economic base over a 20-year period.
>
> Adoption of a plan and initiation of a demonstration program is required now to supplement rail and road development.

Charles M. Walker, Assistant Secretary of the Treasury, announced on April 14, 1976, the Treasury Department's intention—

> "to increase to 12 years the asset guideline period under the Asset Depreciation Range System which taxpayers may elect for aircraft used in contract or commercial carrying of freight or passengers by air. Previously, the guideline period was 6 years. The new period will apply to aircraft placed in service in taxable years beginning after April 15, 1976, unless binding and substantial commitments were made to acquire such aircraft before April 15, 1976.
>
> ### TAX IMPACT OF NEW GUIDELINE PERIOD
>
> The new guideline period will be 12 years, rather than six. However, this will by no means cause a halving of depreciation allowances. First, it must be remembered that taxpayers may choose a depreciation period within a 20 percent range of the guideline period. Thus, the range applicable to aircraft and

associated depreciable assets is being changed from 5-to-7 years to 9.5-to-14.5 years. Second, because present law provides that an asset is eligible for a full investment credit only if its depreciable life is 7 years or more, airline companies have typically chosen to depreciate aircraft over 7 years. It is to be expected that under the new guideline period most taxpayers will choose 9.5 years. Therefore, the overall reduction in the annual rate of depreciation will be, not 50 percent, but approximately 25 percent, and this difference diminishes over the life of the asset.

AFFECT OF CHANGE ON AIRLINE CASH FLOWS

Only that portion of the airline industry's annual expenditures for aircraft and related ground support equipment is affected by the proposed change in guideline depreciation period. The expensive investments of airlines in computers, office equipment, structures and related assets do not fall within the affected asset class. As a consequence, the tax impact, and hence cash flow impact, of the change is strictly related to probable replacement and net additions to the aircraft fleet.

Seven percent annual growth in traffic with *no change* in load factor, and *ignoring* certain tax offsets to be noted below, the following table provides estimates of the investment by airlines for the years 1977–1981 and the probable net reduction in total industry cash flow that would result from the change in ADR life. Note that the estimates of cash flow changes ignore increases in operating revenues which may be expected to be realized via regulated fare increases as a consequence of an increase in this category of costs.

EFFECT ON AIRLINE CASH FLOW OF INCREASE IN ADR CLASS LIFE

	Reduction in cash flow due to change (millions)	Estimate of investment (billions)
1977	$5	$0.2
1978	20	.4
1979	65	1.5
1980	100	1.9
1981	130	2.4

ECONOMIC IMPACT OF THE CHANGE: EFFECTS ON FARES

Changing the airline guideline depreciation period from 6 to 12 years will cause the investors in this industry to increase their effective tax depreciation period from 7 to 9.5 years. Viewing the affected investment prospectively, this change has the effect of increasing the total cost of obtaining the services of aircraft, *i.e.*, there will be an increase in the cost per seat-mile providing aircraft and associated epuipment sufficient (a) to compensate investors at the CAB 12 percent rate of return, (b) to cover replacement cost, and (c) to pay income taxes.

Under present law, the estimated total *capital* cost per seat-mile in the sense just described is 0.802 cents. After the proposed change, this will rise to 0.833 cents, an increase of just under 4 percent. Under present law, the *total* cost per seat-mile is 3.446 cents, and after the proposed change it will become 3.477 cents, an increase of 0.9 percent. The probable effect of the proposed change is, therefore, to cause the level of *future* airline fares to be 0.9 percent higher than they otherwise would be.

Henry C. Wallich, Member, Board of Governors of the Federal Reserve System at the International Monetary Conference, summarized his statement as follows:

1. There is a distinct possibility that a capital shortage may appear in the United States, once the economy moves back to a high level of economic activity.
2. High demands for capital are ahead, mainly as a result of prospective

increases in environmental, energy, health and safety, and mass transit investment. These increases probably will be compensated only in part by relatively modest declines in the share of housing and perhaps of inventory accumulation in total investment.

3. The principal threat of a shortage of investment funds arises, not from increases in demand, but from uncertainty about the adequacy of savings. One source of uncertainty is the decline in corporate profits that becomes apparent once realistic accounting methods are employed. Another is the apparent trend of the Federal as well as of State and local budgets toward larger deficits.

4. Studies that conclude that there will be no capital shortage appear to rely heavily on the assumption that the Federal budget will be in surplus and will be supplying capital to the private sector. Continuation of the Federal financing patterns of recent years would do little to make this hope come true.

5. In addition to the possibility of an overall capital shortage, business may experience constraints in its financing because of the existing heavy burden of debt, especially short-term. In order to strengthen the equity base and facilitate financing, it is suggested that the method of taxing corporations be shifted gradually, without loss of revenue, in the direction of taxing income used to pay interest while reducing the present tax on the portions of income used to pay dividends and retained in the business.

Mr. John H. Winant, President of the National Business Aircraft Association, began his paper with a brief historical discussion of aeronautical R&D.

> NBAA is concerned that there is fragmented control over the R&D support agencies and testing facilities assigned to NASA and the FAA . . .

Their recommendation:

> We think that the cooperative programs should be expanded; however, there should be a detailed review of supporting agencies and a realignment and possible reduction of testing locations and/or facilities.

He next suggested some areas of responsibility in R&D for the agencies, especially NASA's role in civil aviation R&D, stressing that:

> . . . NASA should be a *full partner* with other governmental agencies, particularly those with regulatory powers. NASA should be permitted unfettered opportunity in problem solving without being given predetermined avenues of solution.

Mr. Winant expressed some concern that the FAA's role in civil aviation engineering and development is not what it could be.

Also covered by Winant were the topics of: airport development, a national airport system, the need for trained manpower, training schools, and safety. In the area of National Transportation Policy and Congressional guidance, "The NBAA . . . is seriously concerned about the lack of national policies relating to aviation . . ." Major budget decisions are being made daily in the marketplace by the entire aviation community. These decisions are being made without firm national policies . . .

In closing, Mr. Winant suggested:

> Congress can provide the American public with a more comprehensive view of what the future of aviation will be in this country, assist in delineating responsibilities for specific facets of the industry and direct the publication of policies that will assist those that are in the business of purchasing and utilizing airplanes . . .

ECONOMIC, INSTITUTIONAL & POLICY ISSUES

Characterizations of the Current Status/Outlook for Aviation

In describing the general condition of aviation in the United States, Secretary Coleman said:

> I've noticed that when people want to call attention to something—their industry, or agency or whatever—they often tend to talk about critical periods. That phrase has been used a great deal recently in connection with the aviation industry . . . "We are facing a 'critical' period in aviation."
>
> Now to me, critical has the connotation of a crisis, a real danger period. So I try not to use it, unless that's what I really mean. And I don't believe that we face a crisis in aviation. Far from it. But this is an important time for aviation. For the mid-70's is a transition period for the industry—both the air carriers and the aerospace manufacturers. It is a time of transition—I believe—to a new and productive period.
>
> The carrier industry is moving out of its high-growth stage into a more mature stage—at least for the scheduled segment.
>
> It is moving away from operating with heavy government regulation toward operation under market forces.
>
> The manufacturing industry has been moving away from reliance on the government market toward the commercial market.
>
> As a Nation, we are moving into a period of more deliberate growth, as we attempt to mitigate the adverse effects of economic peaks and valleys, and a high rate of inflation.
>
> The world is moving toward the realization that we have finite resources that must be planned for, conserved, and rationalized.

Manufacturers

John Steiner pointed to a number of factors that have caused a change in the situation facing U.S. manufacturers in recent years:

A. Greatly reduced Government sponsored R&D that is applicable to commercial aircraft, especially in military engine work. Also vast sums were spent on the space program at the expense of aeronautics, a condition that has been only partially corrected in more recent years.

B. A steady growth in the percent of total world commercial airplane sales to non-U.S. carriers.

> Ten years ago, foreign sales represented about 25 percent or 30 percent of the market. Today they represent 80 percent of the market.

Such dependence on foreign sales along with an increase in the ambitions of foreign manufacturers and directed procurement policies by the governments involved has led U.S. companies to cooperate more fully with the foreigners.

C. Financial inability of U.S. carriers to act as the launching market for new airplane programs. Foreign airlines in the past have participated in launching a new U.S. airplane such as Lufthansa did with the 737. But, European governments are urging their airlines, with new forcefulness, to buy European aircraft.

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Frank Borman pointed out that while the U.S. has dominated the world aviation market, we have not been first with many of the technological breakthroughs:

> While this country has no special claim to leadership in basic research, we are the acknowledged leader in the application of that research. We always have been dominant in the commercial aircraft market, as a result of:
>
> The design, production, marketing and management capabilities of our private manufacturing industry.
>
> The presence of a large and growing domestic market, to provide a solid base for product development programs.

Carriers

Frank Borman described some of the factors confronting U.S. carrier airlines today:

> The U.S. airline industry today has an aging aircraft fleet, a large proportion of which is becoming obsolete. As of the end of 1975:
>
> The average aircraft operated by the trunk carriers was seven years old.
>
> Fully 46 percent of the trunk carrier fleets consisted of first generation jet aircraft—short body B–707s, DC–8s, B–727s and DC–9s. These aircraft cost more to operate, consume more fuel per seat mile, and generate more noise than newer technology aircraft.
>
> If we are to improve our fleet efficiency and make our operations more compatible with this country's energy and environmental objectives, we must begin now to implement a program for replacing our older aircraft. Such a program is also essential to maintain an aircraft manufacturing industry which is competitive in World markets.

Secretary Coleman listed some additional factors that have contributed to the problem of poor airline health:

> First, is the cyclical impact of national economic forces on the air carrier industry, which has a high degree of correlation with fluctuations in GNP—with prosperity and recession periods. As a result, net income has been erratic, though it has generally trended down since 1967.
>
> Second, is the long-term slowing in the industry's own rate of growth. The technology-spurred 15% growth rates of the sixties slowed to an average of less than 4% in the seventies. While we expect to see the growth rate increase again, the scheduled industry has moved into a stage of slower, but I believe more stable, development.
>
> Third, is the impact of steadily increasing costs. Not only in the recent high-inflation period (which President Ford's program is now correcting) but long-term cost increases. Expenses overall have increased faster than revenues for the industry since the late sixties. And its two largest cost categories—labor and fuel—have had the greatest increase.
>
> Fourth, there is the presence of excess capacity in the system. Some of the excess is due to the economic downturns of 1970 and 1975. But industry management must shoulder some of the responsibility too. In the late 1950's the industry assumed an annual growth rate of 15%, and purchased aircraft based upon this assumption, which turned out to be wrong. Under the present regulatory system, it had no way of using the resultant excess capacity in an intelligent manner.
>
> Fifth, excess capacity has contributed to low load factors which now are only in the 50% to 55% range.
>
> Sixth, there has been a decline in average yields for the industry. This is due in part to the factor that demand for low-cost, mass travel has grown faster than demand for the traditional scheduled services. Because of regulatory restrictions, the industry has not had the flexibility to respond efficiently to this shift in demand. In their attempts to do so, the airlines have diluted their average yields. We must of course be aware that scheduled services are, and will remain, the backbone of the air carrier industry. At the same time, we are also anxious to see that the low cost, mass or charter market is served responsively and profitably.
>
> Taken together, these factors have eroded the industry's profitability. Since 1967, profit margins have averaged only 2.5%. ROI has ranged from a high of 8.5% to a low of 2.1%. But as I noted above, it has averaged only 5.7%, which compares very unfavorably with the ROI of other industries.

> As profits have declined over the years, the industry has had to turn more and more to debt financing of its heavy capital expenditures. Debt-equity ratios for most carriers now stand well above the 50% level. As a result, the banks and insurance companies, who are the traditional lenders to the industry, have all but turned off the supply of funds. As I said earlier, these observations do not hold true for all the carriers. Some, in fact, continue to be profitable. But, the industry as a whole is looked on as a poor risk. Insurance companies have publicly stated that they will not make further loans to the airline industry until its financial situation is significantly improved.

Projections of the Future of Aviation

Although 1975 was one of the worst years in airline history, Secretary Coleman was optimistic about the future:

> Beyond 1976, we look for a substantial period of economic growth, which should re-establish a trend of both traffic gains and profitability. In particular, I see great potential for U.S. carriers to expand their charter business, the market for low-cost vacation travel in the U.S. being essentially unfathomed. Looking even further ahead, we project that between now and the year 2000, scheduled air carrier enplanements will increase about 5% annually, airport operations about 5.5%, and general aviation operations over 6%.

William Magruder made the following point:

> The world-wide new air transport market through 1990 looks to be over $70 billion, or more than all the history of civil air transport to date.

Andrew de Voursney pointed to the following types of growth factors:

A. Trend growth factors—

> . . . population growth, smaller families, more higher income families, more leisure time, more sophisticated life styles, less use of cars for long distance travel, more foreign visitors to US, low cost.

B. Air travel vs GNP—

> . . . We observe a close relationship between total spending for air travel and overall economic conditions . . .

C. Price of air travel—

> . . . We have estimated that the future price of air travel in real terms can no longer continue to fall. . . . In our opinion the only hope of restoring airline profitability in the near term is through restoration of an adequate revenue yield rate . . .

He predicted the following growth in air traffic:

> . . . We predict that the demand for air travel will increase in dollar terms by 13.4% per year between 1975 and 1981 and by approximately 10% per year between 1981 and 1990. In terms of physical volumes (revenue passenger miles) we are projecting growth of scheduled airline traffic of 5.4% for 1975 to 1981 and approximately 3.2% per year from 1981 to 1990 . . .
>
> . . . We believe that the charter portion of the market will tend to grow more rapidly and will increase from approximately 4% of the domestic market today to well over 10% in the 1980's . . .
>
> With respect to domestic air cargo we believe that the rapid growth rates of the past will not be repeated in the future. Our plans are based on a long range growth rate for air cargo of approximately 5% . . .

SUBSTITUTION OF TELECOMMUNICATIONS FOR AIR TRAVEL

Dr. Gray suggested that air travel growth projections will be affected by technology advances in another field, communications.

> Flying for business purposes constitutes a major segment of airline usage and an even larger segment of airline revenue. It is therefore particularly important to consider technological changes that are likely to affect patterns of business

travel when evaluating the long-term future of aviation. It is the thesis of this testimony that the next 25 years will see a major change in the way in which business is conducted because of the substitution of communications technology beyond the letter and the telephone for transportation.

A number of broad systems studies made since the early 1960's have all indicated that, technologically, the problem of substituting communications for business transportation requires little innovation, although some developments do require improvement for widespread acceptance. It has been found that for most situations, telephone bandwidths are sufficient for both voice and data transmissions. The increasing availability of time-shared computer networks and satellite communications systems add to the capabilities of the telephone network that is in place in the U.S.

It is often argued that human contact, involving visual cues—pressing of the flesh and body language—is an essential part of a business transaction. Extensive work on this question has been done in Sweden and England. The results of this experimentation indicate that personal contact is needed in initial meetings. Thereafter, business can usually be conducted by use of telecommunications as long as there is periodic (every several months) refreshing of the face-to-face contact. These findings imply that many businessmen who fly for regular meetings will reduce the frequency of their face-to-face contacts.

Need for a National Transportation Policy

A carefully formulated national transportation policy is necessary to provide focus and direction for civil aviation R&D activities. John Winant expressed his concern as follows:

> The National Business Aircraft Association is vitally interested in the future of aviation and is seriously concerned about the lack of national policies relating to aviation. We are aware that there has been great difficulty in drafting a comprehensive national transportation policy, but we feel that this is a logical first step and that without it there is great difficulty in determining what R&D is necessary for the future of civil aviation.
>
> Major budget decisions are being made daily in the marketplace by the entire aviation community. These decisions are being made without firm national policies . . .

At the same time national transportation policy is strongly driven by technological options the availability of which is governed largely by R&D policy.

How to Finance Future R&D of New Aircraft

Key Ingredient Needed

Most witnesses and contributors agreed that, in the critical scheduled air carrier segment of the industry, the way to development of new generation aircraft would be open when the domestic carriers returned to good health. In addressing this question Secretary Coleman said:

> The economic problems of the commercial air carrier industry can be summed up in one phrase—its low profitability for the past eight years. Some years have been better than others. Some carriers have done better than others. But the industry return on investment has averaged only 5.7%, far too low to attract the private capital needed for the future.

William Magruder emphasized that:

> The primary need in the civil aerospace industry today is to "get well" as quickly as possible within the present system.

Jack Steiner said that the fundamental constraint on implementation of already existing technology, which could redress many current environmental and energy problems, is poor airline financial health.

Because of their depressed financial condition, airlines are having difficulty raising or attracting capital for new equipment purchases. Frederick Bradley described the situation as follows:

> Looking to future sources of financing, the public markets appear closed to new airline equity securities, due to poor earnings performance and future uncertainties. Insurance company lenders have indicated no interest in extending further long term loans to the industry. Leasing, which has been an important source of financing, is not as available as in the past due to several factors. First, there is a great deal of difficulty in finding equity investors due to the airline situation. Secondly, there is a distinct lack of interest on the part of institutions at this time to provide the long term senior debt for leveraged leases, even with the preferential security of a mortgage on a specific aircraft with a substantial equity interest involved. Lastly, many airlines are approaching the limits on leasing set in most airline loan agreements.
>
> Consequently, banks are fast becoming the sole available source of funds for the airline industry. Many banks are less interested in making loans to the airlines than in the past due to the poor earnings and uncertain outlook of the industry. Also the National and State Bank Examiners have been unusually hard on the airline credits due to the widespread publicity about airline difficulties. With pressure to minimize charges to loan loss reserves, banks are able to find many more attractive uses for their funds. In summary, under present circumstances, the domestic airline industry under present conditions would have difficulty attracting capital for any major new equipment cycle.

Andrew de Voursney described the competition for capital as follows:

> Business firms must be both large and possessed of a better than average financial track record to compete in the future financial marketplace for investment capital. At the present we have no large airlines with an acceptable financial history. Some smaller airlines are relatively strong but the Big Five carriers have financial structures and profit record which put them at a serious disadvantage in competition for new capital.

Bradley pointed to the upstream impact of this.

> . . . in no case has a manufacturer been willing to commit to a new aircraft program and the advance expenditures required without a substantial number of firm launching orders from U.S. domestic air carriers.

Under questioning, he discounted the possibility that U.S. manufacturers would commit to a new aircraft based on foreign orders.

The result of this condition, as John Steiner pointed out is a substantial backlog of technology.

> There have been no new U.S. commercial airplane programs started for about eight years. We did start, some years ago, to re-apply government research back toward commercial objectives. Thus, there is a sizeable accumulation of available but unused research and technology in the U.S. applicable to commercial aircraft. It is noteworthy that the application of this techology, in a new or major derivative aircraft, would be very supportive of current U.S. national objectives. such as fuel conservation, community noise reduction, overall efficiency in the air transportation system, etc.

Witnesses differed widely in their approach to the airline profitability problem: Secretary Coleman, for example, stated that—

> I believe the underlying cause of the problem has been the expensive and, on the whole, repressive impact of outmoded government economic regulation. This has tendered to keep prices to the public up, and to put inflationary pressures on costs. But it has also kept industry profits down.
>
> The long-term solution I have recommended, for the economic troubles of the air carrier industry is reform of the manner in which it is regulated economically. As we have designed it, our proposed Aviation Act will permit efficient airline management to remedy many of the problems I identified earlier. It does this, essentially, by allowing carrier management freedom to make decisions that are

responsive to the market place rather than to a Federal regulatory regime. But it also encourages changes in the system itself.

I am confident that resolution of the airlines' profitability and capital formation problems will be the remedy for many of the manufacturers' problems as well.

Mimi Cutler speaking on behalf of airline passengers supported the need for regulatory reform:

> The major airlines today have enjoyed route protection since the passage of the Civil Aeronautics Act in 1938, have happily adapted to minimum price regulation, and are panicked at the thought of even a measure of free market competition. They predict chaos, price wars, and massive loss of service to small communities. However, we believe that if price competition did force carriers to reduce fares and improve effiicency, more people would be able to afford to fly. The increase in traffic volume would send the airlines rushing out to buy new equipment and improve the health of domestic aircraft manufacturers.

Dr. Miller predicted the affects of regulatory reform on aircraft development:

> I would expect regulatory reform to lead to some restructuring of air services: there would be more "feeder"-type operations into major hub points, with longer hauls-taking better advantage of larger aircraft. Thus, I would see a relative increase in the demand for wide-bodied aircraft (such as the B–747, DC–10, and L–1011) and smaller jet aircraft (such as the B–737 and DC–9), with relatively less emphasis on the standard large, narrow-bodied aircraft (such as the B–707, B–720, and DC–8).
>
> Regulatory reform would also, I believe, lead to the development of smaller, turbine-powered aircraft, with a capacity of between 30 and 50 seats.

Dr. McLucas said that in addition to reform of economic regulations. some short-term measures are needed:

> One way is by increasing efficiency in the use of the airspace. Delays cost the airlines yearly $250–$500 million. This is projected to reach $1 billion annually by 1985 unless new options to increase capacity are implemented. The implementation of the UG3RD is pointed at reducing such delays.

Others disagreed with this answer. Frederick Bradley, for example, said:

> In fact the single most important thing the airlines need is more timely fare increases to cover non-controllable cost increases. On the other hand, the impact of the fare proposals of the proposed legislation and other proposals before the Congress on many carriers is uncertain. As a result, the possibility of the Aviation Act of 1975 or something similar becoming law and the uncertainty of the possible impact on the financial health of the carriers has already had a negative impact on several recent airline financings. However, in our view a more realistic approach by the CAB to fare regulation under the present legislation would have a significant beneficial effect upon the financial community's attitude toward the airline industry.

William Magruder urged the Congress to:

> Stop the present "deregulation fever" in Washington. D.C. and establish reform within the present 1958 Federal aviation act in order to produce:
>
> Confidence in the financial community, making capital available.
>
> Faster CAB response on routes and fares.
>
> An ROI standard that can be used, refined and adopted for long-range planning for capital needs.
>
> More pricing flexibility.
>
> Federal support for our international carriers in their negotiations with international competitors.
>
> Renewed support for small city service to stimulate growth and commerce.

Frank Borman argued that:

> The key to investor confidence is Congressional reaffirmation of the principles of the Federal Aviation Act, which charges the CAB, consistent with the public

> interest, with fostering sound economic conditions in air transportation. We urge Congress to promptly dispose of the Administration's ill-conceived Aviation Act of 1975.

Joint Ventures

For a variety of reasons, U.S. manufacturers are seeking partnerships with foreign companies. Frederick Bradley saw the need for capital as significant.

> One possible solution to this problem is the trend towards international joint ventures between the U.S. manufacturers and major European companies. These joint ventures are attractive as they can tap additional sources of capital, and provide a ready market for the aircraft in the national airline of the country involved. Additionally, the European partner is able to tap the U.S. market which lately has been closed to major European aircraft. The joint ventures are also attractive as they spread the substantial capital risk incurred in a new aircraft and program between two major companies. Certainly, the development of a second generation SST that will be both economically and environmentally acceptable will probably have to be done by a joint venture among the British, French and U.S. The drawback of course would be the dilution of U.S. dominance of the worldwide commercial aircraft market and the resultant impact on our balance of trade.

Jack Hope, speaking for G.E., a company that is currently engaged in a joint venture with France, saw the primary drive toward such arrangements to be based primarily on market considerations.

> It is worth repeating that, in our opinion, the industrialized nations will participate in the world civil aviation market and, with the likelihood of consistent government support, they will go it alone if U.S. industry/U.S. Government do not elect to share the expertise to maintain market position.

When asked what an American firm has to gain from an international partnership, Dr. Weiss replied:

> In my opinion, first of all, capital has become very, very expensive to develop an engine, and of course for an airframe, it is up in the hundreds of millions of dollars.
>
> The cash payoff from a venture now is way out in the future. The outflow of cash is very heavy in the initial years, so it becomes quite risky. So money is very important, it seems to me.
>
> There is a second issue, which is access to foreign markets. Some believe the center of gravity of the aviation market is shifting slightly from the United States to Europe, and perhaps to the Third World Nations. One of the ways to insure participation in jobs in the United States, is for these firms to gain not only capital, but also market access, through joint ventures.
>
> The third reason is weaker. It is our acquisition of some foreign technology—I, myself, believe American aviation is way ahead of everybody in its knowhow. We certainly are, if you look at production efficiency. I think our manhours per pound on an airframe is cheaper than anybody else's but there is some back flow of technology.
>
> I think on the CFM–56, there are some features in the low pressure section, which the French have developed, which I believe the General Electric people think is quite unusual in advanced technology.

New Method for Aircraft Procurement

Frank Borman presented a new concept for the procurement of the next generation aircraft:

> Eastern believes that, if we are to successfully undertake a new aircraft program, we must meet the following conditions:
>
> There must be an assured market, to enable the manufacturers to obtain the financing needed for the development program and to permit an economical production run.
>
> The price of the aircraft must be low enough that it would comprise an economic investment for the carriers. This in turn requires a large market over which to allocate the development cost.

The market must not be fragmented by destructive production competition. We cannot afford another DC–10/L–1011 situation.

The burden of absorbing the initial production must be spread among more carriers, not just a few large airlines.

To minimize the risk of premature obsolescence, we must ensure the incorporation of as much advanced technology as permitted by timing and economics.

It is apparent that we cannot meet these conditions with traditional procurement methods.

The major carriers who historically have placed the initial orders required for a program commitment do not have the financial resources to do so any longer. Further, after their experience with wide-body aircraft programs, it is unrealistic to expect them to place initial orders in the quantities needed to assure an economically viable program.

While competition in the design phase of a program is highly desirable, there is not a sufficient market to support head-to-head production competition. That, however, does not preclude competition among manufacturers with aircraft serving different segments of the market.

Eastern, therefore, is asking CAB permission to hold joint-carrier discussions under the auspices of the ATA, with the objective of:

Achieving a broad industry consensus on a definition of requirements for a new aircraft.

Sponsoring a design competition among the manufacturers.

Reaching sufficient agreement on the results of the design competition to permit the carriers to order aircraft in the quantities needed to permit the winning design to be committed to production.

BENEFITS OF R.&D.

Multiplier Effects of R&D Expenditures

Economists differ as to the amount by which R&D investments multiply in returning jobs, productivity and other benefits. There was general agreement that this phenomenon exists. Dr. Gellman put it this way:

> Given the paucity of data economists have to work with, it is very difficult to be precise in estimating the size or character of the economic multiplier of research and development expenditures. The causal relationships that determine the effects of R&D expenditures are myriad and usually highly complex. Moreover, they are frequently displaced in time and geographically spaced such that they are difficult, if not impossible, to detect—at least with present data. What can be said, however, based on statistical evidence derived from numerous industrial settings and numerous countries, is that those industries and nations which have the benefit of substantial R&D programs seem to fare much better in an economic sense than those which do not have such underlying support for their growth and development.

The Need for R&D to Preserve the U.S. Competitive Position and Balance of Trade

Dr. Gellman summed up the connection between publicly-funded R&D and the U.S. competitive position this way:

> Certainly one of the reasons it is rational to continue substantial public support for R&D in the field of aviation relates to the concept of comparative advantage between nations. Aviation stands no worse than second (to products of agriculture) as a contributor to a favorable balance of payments position for the United States. Obviously the U.S. has enjoyed a substantial comparative advantage in this field. It follows that the United States ought to maintain—perhaps even expand—its primacy in the field of aviation in order to drive home its inherent advantage in this field with the result that aviation will continue to be a mainstay of the achievement or maintenance of a favorable balance of trade for the United States. Because the overall benefits to society are so great from the retention of a favorable balance of payments, it is quite proper for the public sector to sponsor substantial R&D to support an implicit rational objective to lead in the field of aviation.

William Magruder pointed out that it is necessary for the U.S. to maintain a positive balance of trade. This is true because of the commitments to help the underdeveloped nations and people of the Free World. A positive balance of trade is needed to continue this.

Need for R&D to Increase Productivity

Dr. Gellman spoke as follows, in justifying R&D expenditures as a basis for increasing productivity:

> Concerning productivity in more conventional terms, I would once more refer to the material brought together in the National Science Board's latest publication *Science Indicators 1974*. On page 22, this report states that "while the effect of R&D on productivity growth is not known precisely, the general conclusion based on a large number of studies is that the impact of R&D is positive, significant, and high." Not only is this "general conclusion" consonent with logic but it also is supported by a substantial body of circumstantial evidence, some of which is included in this same report between pages 21 and 24.
>
> Referring both to international competitiveness and productivity and their relationship to R&D activities, even though the precise connections are difficult to determine with any degree of precision given the complexity of the relationships and the varying and often great time lags between the undertaking and completion of R&D on the one hand and market introduction of a product or service on the other, it is nonetheless important to recall that there is much indirect evidence that there are important linkages between R&D and these two phenomena. Consequently we should not be asking whether we can afford to continue both public and private sector support for R&D activities in a field like aviation but whether we can afford *not* to support such R&D activities, perhaps even at a higher level than has been the case in the recent past as measured in real terms rather than dollar terms. In this connection, support for R&D on a national level should in the general case be viewed as something as an insurance policy that provides us with the reasonable expectation that we will not be caught dangerously short either in the context of world-wide market competition or with respect to productivity gains. In a sense, to deny public support for certain types of R&D activities (including aviation R&D) would be not unlike the curtailment of public funding of fire companies with the critical difference that in the case of R&D, the lags are usually so very long and the loss of skills so difficult to reverse, that if one subsequently found there was insufficient support for R&D activities, it would be difficult to reestablish a position simply by throwing massive rsources at the problem in the hope of playing catch-up successfully. If there is an industrial area where it is dangerous to be under-funded, it certainly must be that related to the generation of beneficial exploitable R&D results in the field of aviation.

The Need to Promote Competition

Many witnesses stressed the favorable effect on R&D of healthy competition. Dr. Gellman suggested the following as a way of promoting such competition:

> . . . One of the major barriers to innovation in the transport industries (including the airlines) relates to the manner by which carriers purchase the products and services which they use to produce and market transportation. Specifically, it is the execption and not the rule that purchasing functions are carried out in regulated transport enterprises so as to promote the application of the "best" available technology to meet the requirements of the carriers. Performance specification purchasing is a comparative varity in an industry where the reverse should clearly be the case.
>
> By "performance specification purchasing" I mean to convey the concept that there will be maximum competition for the products or services which are to be acquired and that the competition will importantly be couched in terms of the extent to which suppliers are willing and capable of reaching out to the frontiers of technological possibility to meet carrier demands. Especially since the latter enterprises are often regulated in the public interest and may also be subsidized either directly or indirectly, it is important to make sure that they operate at the lowest possible long-run cost consistent with meeting the legitimate demands of the traveling and shipping public.
>
> It is also consistent with public policy that purchasing should be carried out in such a way as to promote competition in the supplier markets rather than to limit

them to those enterprises that only offer products which are little changed over time and which can be produced on the same capital equipment in the same old way. This leads to the specific suggestion that in the course of allocating Federal R&D funds, at least for the next decade or so, there should be substantial explicit stress laid upon the generation of R&D results which will support the development and maintenance of performance specifications which in turn will lead to a high level of effective competition in such markets.

Dr. Ramo argued that competition can be improved by constructing the industrial base:

> For a stable, high quality aircraft industry to exist in the U.S., one benefiting from the advantages of the motivation of free enterprise and competition, a minimum of three independent, broadly based, well staffed and supported aircraft corporations would appear to be required.
>
> The government, without applying force and control, should create an environment encouraging, rather than, as now, opposing mergers, aiming for a few (perhaps three) strong aircraft corporations.

John Robson added the following:

> Two areas deserve particular attention: the direction of future R&D and the institutional arrangements by which R&D receives direction and funding.
>
> A more competitive regulatory environment may influence technological needs, including the character of the aircraft required. The Board believes that one effect of the present system of regulation has been to induce service competition as opposed to price competition. As price competition emerges in the commercial air transport system, one might expect some shift in the character of aircraft required by airlines from those employed in an environment of service rivalry. In the later 1960's most major U.S. commercial aircraft development programs, incorporating very significant technological advances, focused on large, long-range aircraft. This was in part owing to the fact that, under regulation, fares for longer routes and denser markets were higher relative to cost than fares in shorter, lower-density markets. The greater "profitability" of longer, denser markets may have biased aircraft development in that direction. Under greater competition, this discrepancy will presumably disappear. If other types of markets become relatively more profitable, one might expect development aircraft suited for these markets.

THE NEED FOR A STABLE R&D POLICY

Dr. Gellman added:

> I would think that except in rare instances, R&D goals should be established for a relatively long period of time and left undisturbed so there is every opportunity for R&D efforts to result in outcomes which are supportive of the achievement of the stated goals. Perhaps a reasonable interval between review is five years. To be avoided at all costs is a situation where the specific goals of an R&D program associated with a lengthy process of innovation are reviewed so frequently that there is demoralization among the R&D community and there is little chance to achieve exploitable results since even the R&D projects cannot be carried out in an orderly manner.

Ronald Smelt urged that the approach to R&D be balanced:

> An adequately funded, prudently managed, continually updated research and development program of breadth and imagination is essential to the maintenance of U.S. world leadership in aviation. As in other fields of science and technology, to be most effective this effort must be properly coordinated and carefully balanced in terms of emphasis on basic research, applied research, development, test, and engineering. A disproportionately large basic research program may advance the frontiers of the fundamental sciences which underlie aviation technology, but, without a properly matched applied research and development effort, technology (which in the end results in useful aviation products) may lag, to the competitive disadvantage of the United States.
>
> On the other hand, a research and development program which neglects basic research may make short-term competitive gains in useful products but will bog down in the long run because the frontiers of basic knowledge have not been advanced.

THE NEED TO TIE R&D TO THE MARKET PLACE

Dr. Gellman spoke in general terms about the need to couple the total R&D process which leads to innovation, especially the later stages, to end uses:

> With few exceptions, science is most effective when it is pursued with at least a minimal appreciation for the downstream uses of science in the forms of technological possibilities and innovations.
>
> . . . Even the most successful R&D effort will not in and of itself generate employment and economic activity beyond the R&D project itself unless the opportunity presented by the R&D outcome is exploited in the context of a market. This is where "technology delivery" comes in.

Some of the implications of this for government policy were treated by the following:

> Since the innovation process is completed only with the "delivery" of new products (or services) to the marketplace, it is most important that the structure of the technology delivery system be largely market-determined. There are, nevertheless, several very important ways in which the government can effectively foster beneficially technological innovation. One of these relates to public policy towards, and support of, R&D in general as well as in particular fields such as aviation.

Furthermore,

> Perhaps the best way to bring an end to the general failure to couple R&D results to a marketable product or service is to place the responsibility for gaining an understanding of the technology delivery system on those who formulate policy and allocate resources relative to R&D itself. That is, in the context of aviation-oriented public agencies, in the course of their R&D program planning and execution, should explicitly be required to consider, analyze and assimilate knowledge of the technology delivery system both as it related to R&D programs in general and to specific major R&D efforts in particular. This will require a substantial broadening of the present scope of "R&D activities" in an agency such as NASA.

At the same time it is necessary, for the maintenance of a technical reservoir, to commit a certain proportion of resources in a relatively free-form fashion.

> Therefore it is entirely rational to support basic research, and even perhaps some applied research, on the strength of the least precise, most circumstantial sort of "evidence". But as pure research gives way to applied research and to goal-oriented development activities, it becomes more likely that conventional investment decisionmaking methods can (and will) be employed in the allocation of resources.

William Magruder recognized that the Government has a role to play in encouraging R&D that has market applications. He suggested that the Government:

> Provide for tax deductions for R&D expenditures on products brought to successful commercial implementation, thus providing an incentive for successful R&D output where other incentives encourage R&D input.

Willis Hawkins recognized that technology must be used or its sources will dry up. Therefore:

> To accelerate "the utilization of technology, the solution is to find some way for incorporating this technology into saleable articles and to make it possible for operators to purchase such equipment.

NEED TO COUPLE R&D TO USER REQUIREMENTS

William Ottley argued in the following way regarding FAA activities:

> There has been all too little opportunity afforded the user community to provide inputs to the R&D planning process. The FAA is not altogether respon-

sible for this situation, as some of the blame must rest with the users, but the fact remains that there has been all too little dialogue between the Agency and those it serves insofar as requirements and discussion of programs are concerned.

An effective procedure must be developed by which user inputs and constructive comments with respect to Agency programs can be channeled into the planning process. The suggestion has been made to develop a Notice for Proposed Research Program (NPRP) to be published in the Federal Register and on which comments are solicited in much the same manner as the NPRM. Admittedly, there are bureaucratic problems which might develop from such a procedure, but if care is taken in the development of the procedure they could be minimal; at least user input would be assured.

NEED FOR A FOCAL POINT IN THE EXECUTIVE BRANCH FOR AVIATION

Several witnesses and contributors indicated a need for a top level focal point in the Administration for aviation policy. For example, Dr. Fletcher said that, while coordination among agencies at the technical level was excellent, better arrangements are needed at the policy level.

Dr. McLucas agreed:

> I think the overall coordination of our activities needs more attention. We all talk to each other on an informal level and through these various committees that have been set up between NASA and DOD, between NASA and FAA, and among all three of these agencies, to discuss different kinds of problems, and the difficulties at arriving at the concensus and decisions which we can all follow. But on the policy level I think there is a serious lack. I have not seen very many meetings what I would call a policy level, but broad policies were discussed and settled on among the different agencies involved.

He singled out the area of military/civil R&D coordination as one that could benefit from greater policy-level interaction:

> I think we need better cooperation between the civil side and the Department of Defense on engines such as the CFM-56 and JT-10-D's because they do have requirements for new aircraft which could use these new engines. And at the same time if there is only a Department of Defense requirement, the impetus to get on with it might be considerably less than it would be if we both put our shoulders to the wheel and start pushing in the same direction. So I go back to my statement that I think there is not enough policy interaction between the civil and the military sides with respect to aviation developments.

General von Kann offered the Air Transport Association's view as to the appropriate institutional location for an aviation focal point:

> We believe that a focal point in government is needed to assure that a policy of U.S. aviation preeminence is carried out. We need to do a better job of coordinating the aviation responsibilities of all government agencies in order to make that policy work. Several witnesses have wondered where in government this focal point should be established. There are several possibilites—in the White House, in the Department of Transportation, in FAA. In my personal view, the most simple and direct course would be to strengthen and augment the role of the FAA Administrator and to charge him with the responsibility and the authority to pursue a coherent policy of the United States aeronautical preeminence.

NEED FOR A NATIONAL GOAL

As a first essential step in formulating policy, William Magruder argued for the establishment of a national goal:

> *National goals* are essential for the focusing of governmental and public attention and effort. Need a national goal; we need to be evaluated fairly and openly based upon the balance of good things we provide the nation and the world so that these contributions to our society are not lost in the minute examination of the few warts that we, and all other institutions, exhibit in our failures to reach perfection.

He offered the following as a "strawman":

> To provide low-cost, economic, safe, quiet and clean transportation of people and goods readily convenient to all destinations within or without the continental U.S. that have a clear need, and to provide augmentation for our military airlift system.

The benefits of this goal could also be stated as:

> So as to encourage the communications and commerce of our citizens throughout the Nation and the world and then realize the benefits of this communication and commerce in conditions that promote peace, a healthy society and a strong U.S. economy able to compete in the world.

Dr. McLucas suggested that the national goal should include maintenance of our international lead in aviation. He gave the following reasons:

> The first one that occurs to me is the national security and the role which aviation plays in national security. Also, the balance of payments situation is affected to a great degree by how well we maintain our lead because this determines how well we will do in selling airplanes abroad. The third effect, which is obvious, is that of jobs. The aviation industry is a major employer in the country. And, fourth, I would mention that I think aviation is a dynamic force in our economy overall because of the high level of technology and innovation which characterizes this particular industry. Fifth, I would list certain nonquantifiable factors, such as leadership and what this means to us from the psychological standpoint.

Need for More Timely Regulatory Action

Mimi Cutler pointed to the need for speedy decisions on proposed regulation:

> We do not dispute the FAA's contention that it must proceed with caution. However, federal regulation which drags out critical research and policy decisions for 5 years or more retards the creation of new technology and the implementation of improved safety features. In our view, aviation research and development policy requires a reinvigorated and responsive FAA.

Russell Train emphasized the need to establish environmental standards early to provide the incentive for manufacturers to incorporate the best available technology in their designs.

> . . . we believe that guidelines should be provided to the industry to assure that future production vehicles utilize the beneficial results demonstrated by aggressive R&D programs. While designers of new aircraft and new engines do attempt to incorporate the latest R&D achievements, standards for noise and exhaust emissions are still necessary to avoid trade-offs when such emissions might be given low priority in the overall design in order to improve other parameters.
>
> I believe the aircraft manufacturers need to have the Federal Government establish national aircraft environmental standards in a manner which will give them adequate lead time to adjust their design and production processes and assure them a ready market for these quieter aircraft. Significant improvements in technology will be possible in the future, and the Federal Government must project these improvements and codify society's expectations into mandatory environmental standards with sufficient lead times. The practice of waiting until the new technology is being used by some manufacturers and then legislating its use by all has not provided the environmental protection which we have needed; and it has not given the aircraft manufacturers firm design targets.
>
> In support of this, a comprehensive Federal program of research, development and demonstration is required to permit a periodic reduction in the allowable levels. Based on our current knowledge, even an instant application of all present day technology will not provide a complete solution to the aviation noise problem.

GOVERNMENT ROLE IN R&D

CRITERIA FOR GOVERNMENT INVOLVEMENT

With regard to the proper government role in the development of new air transportation systems, Secretary Coleman said:

> I believe the basic role of the Government is to create the proper climate for healthy private operations. And I believe we have gone to the root of the problem by proposing the regulatory reforms contained in our Aviation Act. I do not believe that the Government should finance the development of commercial aircraft. On the other hand, the Department of Transportation may properly take a role in long-range R&D.
>
> The criteria the FAA will be using are those identified in my Statement of National Transportation Policy:
>
> Would the public interest and Federal priorities be served more effectively by alternative uses of the Federal dollar?
>
> Could the need be met as effectively by the private sector or by another level of government? Are there alternative sources of financing?

Dr. Gellman stressed the following objective of Government participation in R&D:

> . . . one overriding objective of R&D policy, technology policy, or innovation policy should be to preserve the conditions under which the private sector increasingly bears responsibility for R&D the further one gets from the conception or invention end of the innovation spectrum and the nearer the one gets to the marketplace.

Dr. Stever posed a series of questions that can be asked with respect to all government investments in R&D:

> 1. Are incentives for private industry to invest in particular R&D projects inadequate?
> 2. Do substantial benefits exist which are noncapturable by any one private firm doing R&D?
> 3. Are there substantial social benefits (i.e. benefits not capturable by the firm which accrue to the public at large) which would more than offset the costs that government and industry might incur in conducting the R&D in question?
> 4. Do these social benefits exceed those that might flow from other R&D projects?
> 5. Is the project basic research?
> 6. Is there a long time horizon for research and development before any returns will be obtained from the investments in R&D?
> 7. Are technical risks associated with the R&D high?
> 8. Is the new technology being developed unlikely to be marketable at a profit?

The NASA "Outlook for Aeronautics" contained the following discussion of the Government, and especially the NASA, role in R&D:

> In recent years, a number of factors have arisen which give emphasis to the importance of a continuing involvement of government in aeronautical research and development. The increasing pressure to adopt more stringent standards that will make air transportation safer and more accepted environmentally, the growing foreign competition, the increasing cost of making adequate research and development investments, including facilities investments, all point to the importance of a continuing government involvement. If the U.S. is to retain its present position in civil aviation product development and sales, it is clear that the government must continue its support of research and advanced technology.

> In addition, it may be necessary for the government to sponsor the initial design and development efforts for some civil aircraft, in order to permit the industry to be in a strong position to compete in the future.

Dr. McLucas posed the problem in the following way:

> Many people question specific suggestions that are made as to how the government can play a part in making sure that we maintain our lead. People question the desirability of direct government funding of such things as complete prototypes of new aircraft designs, demonstrations of technology of one form or another, but I do not believe that they question the role of the government insofar as basic research and development is concerned. It is only when you get beyond the basic R&D that you begin to get into questionable areas. And I think that one of the main purposes of these hearings is to decide where is the proper dividing line between those things that we think are appropriate for government funding and those things which should be left to private industry. But I believe none of us questions the role of the government in policy setting, and developing guidelines and goals, and especially in the creation of a climate in which the right things can be done at the right time.

He further referred to the substantial flow of technology that has resulted from military developments over the years (see Military Fall-out). He said that the level of this transfer may be declining somewhat because of differing requirements. Therefore,

> To the extent that technology is not covered by the military, NASA and FAA are going to have to pick up the ball. And NASA is the obvious agency to do the work that needs to be done on the new, quiet, clean, efficient engines. But on the production side I do not see that there is a role here for FAA and NASA. We just do not get into that kind of business. A prototype it seems to me is a possibility. And I think there is room for differences of opinion here which need to be discused more thoroughly.

Dr. Stever gave the following criteria for potential government investments that are not designed as income transfer of welfare programs:

> 1. The benefits to society of a Federal investment exceed the costs imposed on society by that investment.
> 2. The net benefits or net return from the investment is at least as great as the net benefits from alternative investments the government could make.
> 3. There is inadequate incentive for industry to undertake the proposed investment if government does not.

SUPPORT OF BASIC RESEARCH

The traditional role of government in the R&D progress has been in the support of basic research. Dr. Gellman justified this by saying:

> In general, direct Federal support provided at the upstream or pure research/R&D phase of the process of innovation is most justifiable since, other things equal, the externalities are relatively greatest there. As one proceeds through the system of technology delivery for civil, private-sector innovation, the benefits of the investments in technology and innovation become more "capturable" by the private sector so that less direct federal support in the form of grants or contracts is required or is justified.
>
> Furthermore, the greatest financial risks in the process of innovation are often found in the earliest stages, including especially basic research. Since private sector investors rationally abhor risk, it is not unreasonable that, to the extent the public sector funds activities in support of the process of innovation at all, such support should be heavily concentrated in the high-risk areas such as basic research.
>
> Also, the time horizon for private entrepreneurs is substantially less than that for Government which makes it rational for the latter to support those activities associated with the process of innovation that have the very longest lead times and which therefore represent relatively unattractive investment outlets for private capital.

Frank Kolk made the following plea for basic research:

> The military has become extremely project oriented. As a matter of fact, so has the civil sector. This has resulted in a situation where most of the money, most of the encouragement, and most of the support is associated with project oriented work. The idea of going out and thinking up something new in the abstract seems to have been lost and we have no particular encouragement from our government and from our people to invent something new. I make a strong plea for the encouragement of aeronautical technology in a pure sense to understand more about what we are doing and to allow this understanding to create new ideas which we can bring to the surface and develop without hitching them to a *PROJECT* or a *BUZZWORD* or a *SLOGAN*.

Frank Borman distinguished research from development by defining it "as a fundamental broadening of the base of knowledge". Since it should always be directed toward societal objectives:

> It is only natural that the primary sponsor should be the government. Many of the facilities required are too complex and expensive to contemplate their multiplication throughout the private sector. Furthermore, coordinated and collected knowledge will be much more effective than that which is developed on a random basis and then withheld for proprietary reasons.
>
> We would urge Congress to ensure that NASA has sufficient funds to pursue a vigorous program in the following major areas, listed in order of priority:
>
> Reduced energy consumption;
> Reduced noise and emissions;
> STOL;
> SST.

THE NEED TO REDUCE BARRIERS

Dr. Gellman:

> The support that becomes most meaningful—and most important—as the technology delivery system gets closer to the market is related to removing barriers to the completion of the process. While this may require public expenditures for facilities needed to prototype or test equipment or components, the barrier-removal role of Government is generally of a different character and is no less critical than is Government's role as sponsor of pure research and R&D activities earlier in the process.

As examples of this he posed the following questions:

> . . . does Federal policy which severely limits the exclusivity available to Government R&D contractors with respect to patents, data and knowhow constitute a significant barrier to the translation of R&D results into viable products and services? At what point in the technology delivery system and in what ways do regulations of various sorts interfere with or completely thwart the technology delivery process? These and many other questions should be considered in the course of formulating policies related to R&D, to technology and to innovation.

Anti-Trust Laws as a Barrier

As one alternative to the move by U.S. manufacturers to seek foreign partners, Dr. Gellman proposed the following:

> In order to generate enthusiasm from the airframe producers (and perhaps in the engine area as well) it may be necessary to allow otherwise competitive firms to get together and form a joint venture or consortium which would then develop and produce the aircraft the market has been judged to require. If a situation arises where the choice is between U.S. participation in multinational consortia and an all-U.S. cooperative venture between otherwise competitive manufacturers, I suspect the latter is the better solution to the problem, all things considered. But the public policy issues must be identified and resolved one way or the other—and early rather than late.

When asked about the merits of this possibility, manufacturers discounted the implicit anti-trust considerations saying that the real urge to form foreign joint ventures was brought about by a need to secure market access.

Thomas Kauper summarized the Justice Department view as follows:

> Basically, antitrust analysis of joint ventures requires a determination of whether there is a loss of competition caused by the combination of competing or potentially competing firms. Even if there are some anticompetitive effects, a joint venture may be allowed if it provides procompetitive benefits which are more substantial than its anticompetitive effects. In the aviation industry, many markets are quite concentrated, giving rise to antitrust concern about loss of competition from combination of the very few actual or potential suppliers of given products. On the other hand, the substantial business risks and technological challenges the industry faces are such that some innovations might not take place without joint ventures, and innovation is a vital aspect of the competitive process.

Dr. Weiss when asked whether U.S. joint ventures should be encouraged, referred to the following disadvantage:

> If I were to give you a very quick opinion, in the long-term interest, I don't think so.
>
> I think we need to have competition in the United States.
>
> I think it sounds, not only pleasing, but sort of helpful if we could arrange to have our firms consort, because they are up against legal foreign cartels, but the implications of that, I think, are pretty deep, and would have to be really thought through very, very carefully.
>
> I think our firms are sufficiently strong that they can hold their own in the world market, assuming the R&D is supported; (but) to assume that they cannot hold their own, and change the anti-trust laws, I think that would reduce competition and probably some of the incentive for quality work would probably be hurt.

The effects of Regulation on R&D

Dr. Gellman:

> Among the elements in the process of innovation which lie downstream from the successful completion of R&D are many aspects of regulation. To the extent that such regulation promotes or thwarts the translation of R&D results into viable products or services, then such regulation is highly revelant to those who allocate resources to R&D activities and to those who carry out R&D projects. Since a very substantial portion of the innovations in the aviation field are greatly conditioned by the extent and character of various sorts of regulations, it follows that such regulations profoundly influence the nature and thrust of much aviation R&D.
>
> Fortunately, there is now a growing awareness that economic regulation does have an effect on technological change and innovation in regulated industries even though such realization has not yet been translated into any mechanisms to assure that the process of technological innovation can be more efficiently carried out in such regulated industries. It would be a substantial contribution to improving the innovative performance of such industries, including the airlines within the transportation field, and it would also enhance R&D productivity, were the Congress to take steps requiring explicit consideration of the effects of economic regulatory policies and decisions upon technological change and innovation in industries effected by such economic regulation. To this end I have suggested before and will suggest once more that it is of considerable importance to introduce into the economic regulatory process the concept of the technology impact statement.

Dr. Gellman stressed that regulation can also be a catalyst to the exploitation of R&D results. He and George Eads proposed the following solution:

> Some means must be found to correct this situation. Perhaps consideration should be given to requiring that U.S. Government agencies charged with regulating various segments of the economy be required to produce "Technology Im-

pact Statements", analogs of the Environmental Impact Statements that currently must be prepared to accompany their major policy decisions.

Tax Policy

As an example of the inhibiting effects on R&D that can result from tax policy, Frederick Bradley cited the following:

> [The uncertainty] problem is worsened by the recent Treasury Department ruling stretching the minimum depreciable lives for aircraft from six to twelve years. This ruling will have a varying effect on different carriers depending on each carrier's current depreciation policy and tax status; at best, there will be no effect, otherwise it will mean a lower rates of return on aircraft investment.

Dr. Heiss urged a change in accounting procedures related to depreciation:

> Real capital formulation (for the aerospace industry) needs to be reinstated as the cornerstone of economic growth, and as the basis for the demand for new technology assets, and can only regain the status if the illusion of historical cost accounting is recognized as a destroyer of capital in periods of continuing inflation.
>
> In the ten year span 1965–1974, real depreciation costs of the U.S. aerospace industry were higher by a total of $1.1 billion than the nominal depreciation costs stated in industry accounts; nominal depreciation costs were $5.7 billion, real depreciation costs $6.8 billion. This discrepancy caused an overstatement of corporate income taxes by $543 million (out of a total tax bill of $4.6 bill) and a liquidity outflow of about $1.7 billion.

Bill Magruder submitted the following list of tax measures that have potential for stimulating and encouraging more effective R&D:

> (A) An investment tax credit of 7 percent to be paid to professional R&D personnel as a means of countering potential disincentives of the capital goods tax upon the capital goods of R&D.
>
> (B) A 25 percent credit to private firms for grants made to university R&D to provide a tie between industry and university R&D that does not now exist.
>
> (C) Provide cash payments to private firms in the amount of unrealized benefits from tax provisions intended as incentives for R&D expenditures, thus providing stimulation to small firms and new ventures whose profit levels prevent incentives from tax credits and even tax deductions.

Frank Borman recommended:

> Amendment of the tax laws to provide prompt refunds of investment tax credits which cannot be used because of the lack of earnings.

Trade Policy

Government policy with regard to foreign trade can represent a barrier to aviation industry sales and therefore to private sector R&D. Floyd Smith recommended:

> Intensification of efforts to eliminate tariff and non-tariff trade barriers; (and) insuring that adequate financing at rates competitive with those offered by other nations is available for both civil and military exports; and progressive liberalization of trade practices and enhancement of the exporting environment, keeping in mind the need to protect both American industry and the jobs of American workers from export overseas.

George Eads described the role of the Export-Import Bank in promoting foreign sales of U.S. aircraft:

> The Export-Import Bank participates substantially in the financing of virtually all aircraft sold overseas. This participation is not limited to aircraft sold to underdeveloped countries. Airlines in Japan, Switzerland, Scandinavia, and the Netherlands have all received Eximbank assistance in financing recent wide-body jet acquisitions. The availability of such financing can have a substantial impact on the demand for aircraft.

NEW FORMS OF GOVERNMENT PARTICIPATION PROPOSED

New forms of Government participation in the R&D process may be required because the development costs of new aircraft have grown along with their sophistication as well as other economic factors. John Steiner put it this way:

> . . . the "break throughs" that we know lie ahead, frequently involve financial development costs and commercial risks which are too great for any private industry to accept.

Ronald Smelt proposed a role for Government in demand estimation:

> Much will depend on vigorous and enlightened Government cooperation and support. Government activities of many different kinds affect the prospects for exports of aeronautical equipment. While many manufacturers have their own sources of market information, few can cover developments all over the world. Appropriate personnel in the Government's embassies and consulates can make a most important contribution. They need to be alert to opportunities for sale of U.S. aeronautical products—military and civil—and the information they acquire must be passed on expeditiously.

Dr. Gellman suggested the following:

> . . . prototypes of aircraft or major aircraft components are typically very expensive both in terms of time and capital resources. In order to broaden the base of enterprises which engage in technological developments relevant to aviation, it might be rational public policy to promote the development of prototypes. Again, aviation perhaps has the strictest test requirements related to the transfer of technological possibilities into viable products and such testing is necessarily expensive and arduous, typically requiring highly specialized equipment and specially skilled personnel. It may very well be that under the circumstances, the government should explicitly and routinely undertake to test prototypical aviation hardware if it is thought that in the absence of such "service", the process of innovation will not be exploited as fully and as effectively as would otherwise be the case. The same holds if the barriers to entry into the aviation supply field by private enterprises are sufficiently great because of the prototype and testing investment requirements that there is less competition in the markets for aviation products than is healthy for the future of aviation.

William Magruder proposed that the military concept of Independent Research & Development (IR&D) funds be extended to cover R&D on any problem of national interest rather than being restricted to mission-oriented military R&D.

Transport Development Bank

Several participants made similar proposals for a transport development bank. Floyd Smith phrased it as follows:

Among the elements which should be included in any new national R&D policy should be the following:

> Establishment of an independent government financial organization such as a "national technology bank" which would provide the private sector with financial aid, either through guarantees or direct loans, for the purpose of stimulating additional private investment in R&D for both public and private programs of national and international importance to the U.S. Innovations and technology resulting from this federally sponsored R&D should be considered part of the public domain.

Expansion of NASA's Role

John Borger described a traditional feature of the NASA/industry relationship:

> Sound basic research by NACA and its successor NASA has been translated by the manufacturers into operating airplanes. All of the manufacturers have found

it advisable to have their own research facilities, but these are usually more specialized and used for testing specific configurations and design refinements.

Because of this, John Steiner saw the possibility of an expansion of NASA's traditional function of developing technology especially in the advanced composites area:

> Commercial operation requires guarantees and service life policies that extend over a great many years. No commercial manufacturer will enter into such guarantees until the subject involved is fully proven. Thus, even if research provides the technology required to produce and incorporate significant usage of composite structures in a commercial product, the necessity for service life policies and guarantees will require additional R&D work. Such work presents a challenging goal but the rewards of 20% to 25% reduction in structural weight are certainly worth the effort.

General von Kann expressed support for this need for NASA to carry its work somewhat further than it has traditionally done—

> . . . to carry ideas not only to the feasibility stage, but also to prove concepts and to carry them to the certificable level. This does not mean prototype development, but it does mean that the technology elements whether they be new landing-gear concepts, composite materials, or new structures be carried to the point where they can be picked up by aircraft designers.

John Winant made the following observations and suggestions regarding NASA's role in aviation:

> . . . . It appears, however, that other government agencies, (e.g. FAA, EPA) have not fully utilized NASA's abilities to seek solutions, but rather have used NASA to examine a given problem for which the solution has often been predetermined.
>
> . . . NASA should be a full partner with other governmental agencies, particularly those with regulatory powers. NASA should be permitted unfettered opportunity in problem solving without being given predetermined avenues of solution.
>
> The Subcommittee should give serious thought to indicating that NASA, the foremost research agency, in the national aviation structure must be consulted more fully in developments affecting U.S. aviation.

FUTURE NEEDS AND OPPORTUNITIES

Dr. Lovelace pointed out:

> The adoption of new technology advances can be influenced strongly by economic, energy, environmental, and regulatory considerations. Nevertheless while aviation may not exist on technology alone, it certainly cannot exist without it.

It is appropriate therefore to devote a section of this report to future technological needs and possibilities in the air transportation system.

NASA Study "Outlook for Aeronautics"

The study identified the major factors that will influence civil and military aviation in the future:

Civil

1. Increasing costs of air transportation
2. Congestion of the air system
3. Foreign competition in advanced aircraft

Military

1. Reduced access to overseas refueling sites
2. Fewer foreign logistics and staging areas
3. High cost of new weapons systems

In response to these factors, the study identified the primary directions in aeronautical development:

> *Civil aviation.*—(1) The increasing costs of air transportation will drive new developments in subsonic aircraft toward greater efficiency and economy while improving safety. Representative aircraft developments foreseen for the 1980's include both derivative versions and new long haul and short/medium haul subsonic transports, and improved general aviation aircraft. (2) The congestion of major hub airports anticipated in the 1980s will give impetus to the introduction of short haul aircraft that can use smaller regional airports. Aircraft developments foreseen include quite, efficient transports capable of operation from shorter runways, followed by intercity VTOL and rotorcraft transports in the 1990s. (3) The introduction into service in 1976 of the Concorde supersonic transport requires that the U.S. give renewed serious consideration to its impact on U.S. leadership in civil aviation. It is clear that substantially more technology must be developed in order to keep open the option of competing in the world markets for supersonic aircraft.
>
> *Military aviation.*—(1) The need for the U.S. to maintain a worldwide military logistics capability, by sea and air transportation, will require the development of long endurance and very log range subsonic aircraft. These aircraft will allow ocean surveillance from the U.S. and permit U.S. based forces to be deployed when necessary without the use of intermediate refueling sites. (2) Reductions in the number of permanent overseas bases used as logistics and staging areas will require the development of multi-mission rotorcraft and VTOL aircraft for naval and limited land-based operations. (3) The high cost of weapons systems will force the introduction of more effective tactical weapons systems, lower cost fighter aircraft, the use of lasers for improved communication and fire control, and the widespread use of remotely piloted vehicles.
>
> Progress in these directions will depend critically on the extent to which the necessary technology investments are made.

Furthermore the study concluded that:

> Success in conducting research and in developing advanced technology for the future depends directly on the quality of available methods, techniques and facilities. This is particularly true in aeronautics where safety and economic considerations dictate that a high level of confidence be achieved before new technology is incorporated into the end-product. The U.S. aircraft that have been introduced into service since 1955 benefited from the aeronautical facility investment made by the NACA (the predecessor agency to NASA) in the years 1940 to 1955: over 560 million (1975 dollars) were invested in the construction of facilities in that 15 year period.
>
> Since 1955, however, the pattern of facility investment has been markedly different; the 15 year period 1955–1970 investments in aeronautical facilities amounting to only 130 million dollars, with the result that our ground based facilities can no longer adequately simulate the conditions that will be experienced by the next generations of civil and military aircraft. The highest priority must be given in the years ahead to the construction of modern aeronautical facilities that can provide the basic information necessary for the design of our future aircraft.

TECHNOLOGY AREAS NEEDING EMPHASIS

Aircraft

Dr. Cortright testifying on behalf of the American Institute of Aeronautics and Astronautics identified several areas of technology that need emphasis now to assure that the nation retains its options for the future. These options include fuel-efficient conventional subsonic passenger and cargo aircraft, economically viable short takeoff and landing (STOL) aircraft, vertical takeoff aircraft and supersonic transports. Some of the technologies that are critical to the development of these aircraft are: advanced materials, active controls, powered lift, laminar flow control, advanced engine components and variable cycle engine technology.

John Steiner addressed some of the technological advances which are considered important to the Boeing Company:

> A. One of the more challenging areas of fuel savings and economic improvement is the installation of laminar flow control on commercial aircraft. We have tested enough to know that the improvements are real. We don't yet know how to put them into a commercially viable system. If we spend the required amount of money, such aircraft could get into operation before the year 2000. The potential of 25% to 30% of fuel saving is certainly worth the investment.
>
> B. Another area of massive improvement lies in the application of composite structures to commercial aircraft. NASA is already orienting a large portion of their budget toward this end.

Airways

In the area of air operations, Dr. Cortright indicated that higher levels of automation will be required to accommodate the projected traffic growth. Airway moderization will also depend on increased attention to human performance in the use of sophisticated equipment and aircraft optimization for terminal operations.

Dr. McLucas, speaking of the long-term outlook for the airway system, said:

> The projected growth of aviation, continued operational developments, and new technology require that long-range research be conducted to meet future needs. Even the most conservative growth projections indicate that the UG3RD will become inadequate by the 1990's. Therefore over the next few years we expect to significantly increase our long-range research activities.
>
> The FAA long-range research program for the National Airspace System is designed to find ways to minimize expenditures of manpower, energy, and other

> resources, in the post 1990 time period. The long-range research program will develop the key elements needed for implementation of a fourth generation ATC system. It is envisioned that some form of massive automation of the basic control process will be needed to stem rising manpower requirements. New control techniques will be required to provide adequate capacity. Integration of system functional elements of surveillance, position fixing, and communication will be necessary to keep system costs low. Extensive tradeoffs between ATC system elements will need to be performed to minimize both system costs and airborne equipment costs. Identification of long-range research goals must be made now because of the extensive lead time required to complete the analysis and experimentation before the decision can be made to develop, test, and implement major elements in the national airspace system.

John Steiner identified four dimensional navigation as an example of technology that will be needed and can save between 5% and 10% of total system fuel:

> Four dimensional means, of course, that we control each flying unit not only as to its position in space, but also as to its position in time. The total system is known by many names, one of which is Strategic Control but, in any event, its installation would mean that aircraft follow prescribed paths and that their actual position in space be updated in a central computing system with ground-air data links.

Glen Gilbert saw the need to relieve airway congestion, especially around airports:

> Should the wake turbulence problem not be alleviated, saturation of these key airports will occur at an even more rapid rate than projected.

Airports

Dr. Cortright said that more work is needed in solving ground side problems, as well, if serious congestion is to be avoided. Such areas as intermodal terminals, airport access, security and baggage handling are important.

John Winant stressed the need for further study:

> Research and development in airport and airport-related facilities has been so lacking that it is nearly impossible to define where to begin; however, NBAA suggests that consideration be given to priority study of optimum land use development and airport configuration for various combinations of air carrier/general aviation mix.

Neil Armstrong added this:

> A pavement R. & D. program must be structured to provide sustained annual allocation of funds that will permit the emergence of an effective nondestructive testing program and the evolution of a rational pavement design.

Environmental Needs

Russell Train discussed the need for incorporation of the latest noise suppression technology in future aircraft designs:

> Initial cost, in a new product, normally is reflected in the degree of advanced technology utilized. Operating cost is related to fuel usage and system maintenance, among other things. A by-product of these considerations may be reduced noise; however, this parameter has never been one of the driving design criteria. We believe that future systems should consider noise reduction as a basic design goal in conjunction with the cost and performance criteria. If noise abatement goals do not reflect the best attainable technology, then the benefits to the airlines, due to improved performance, may not be fully realized since operational restrictions at airports may drastically inhibit the operational flexibility the airlines require to provide the profit benefits.

William Ottley, in outlining national priorities for civil aviation R. & D. emphasized that:

> The environmental area is critical, with first priority being assigned to noise; and right behind it the question of emissions. Again, a team approach is recom-

mended, whereby FAA, NASA, and EPA would be assigned their respective responsibilities by an impartial group. In this connection, the whole question of operating procedures in the noise problem area is an important one, and a joint FAA/NASA effort would be sound.

NEED FOR INCREASED FEDERAL SPENDING

Several witnesses and contributors commented that the overall level of federal expenditures on civil aviation R. & D. was too low. Dr. Cortright, for example, said:

> Satisfying (the needs of a sound and progressive national civil aviation program) requires federal funding well in excess of that now accorded NASA and DOT.

John Steiner added:

> The total need for development toward better commercial airplanes is vast. The fact that we have done relatively little for some years has placed us in a position where we, as a nation, have no significant advantage in technology over foreign competitors. Regaining our former techological lead may, in fact, be impossible. It certainly is no use to follow a policy of isolationism since a great share of the market is in foreign areas, and such policy would, of course, exclude us from those markets and reduce American jobs. As someone once said "we must simply run faster." Running faster requires government-sponsored technology development in conjunction with industries' capability to integrate the results of basic research into viable economic products. It would seem that the size of the market and the balance of trade effects that it has, would justify ambitious programs in all of the areas noted on the chart.

Karl Harr discussed the need for greater government funding of R. & D.:

> Government support for civil aeronautics is presently minimal. At the same time, as has been said, our foreign competitors are enjoying an increased emphasis on R. & D. In the 1967 to 1971 period, while the U.S. realized only a 16 percent growth in Government R&D expenditures, France, Germany, the United Kingdom, Japan and the USSR experienced rates of 27, 82, 21, 147 and 61 percent, respectively. Recognizing the potential of civil aircraft sales for their balance of trade, these countries have established policies which generously encourage R. & D. specifically aimed at civil transport aircraft development.
>
> Obviously technical leadership is not the only ingredient essential to the development of successful transport aircraft programs, but the benefits available to countries which successfully market transport aircraft will not be available to those without such leadership. The governments of the countries cited certainly appear to have reached such a conclusion. Thus, it is the belief of the aerospace industry that our Government should develop and adopt a policy which would clearly support aeronautical R. & D. for application to the development of civil transport aircraft. The basic aim of this policy would be to insure that the United States retains its position of leadership in the marketing of such transport aircraft.

John Hope stated it this way:

> Maintenance of technical superiority is thus accomplished most effectively by active, continuous replacement of existing "old" technology through programs of R. & D. rather than by attempting to preserve existing—and therefore obsolescing—technical capabilities.

Floyd Smith added:

> American industry has indicated its awareness of those problems by increasing its own funding of R. & D. Yet with all its enormous growth, the federal government has slackened its participation in this critical area. Government funded R. & D. in the U.S. has declined from 1.9% of the GNP in 1965 to only 1.2% in 1974. In real dollars, this has meant a 16% decrease over the past decade, substantially weakening the creative government/industry/university partnership of the 1950's and '60's.

Furthermore: A recent Department of Commerce study points out that "the United States is perhaps the only advanced nation in the free world which has not undertaken national programs to stimulate technology development in the civilian sector." The study also notes that other governments not only fund industrial research but also provide tax incentives, interest free loans and grants to stimulate the development and world wide marketing of innovative products.

SPECIFIC PROJECTS RECOMMENDED

Advanced SST

Several witnesses were asked about the desirability of developing an acceptable U.S. supersonic transport and about the time table involved. Dr. McLucas responded in the following way:

> When I have been asked to speculate about when I think these hurdles would be overcome so that we could actually lay down and design, and get a finished product off the line, I have said I do not think this will happen before 1990.
>
> If you accept the fact that we do not have the technology in hand today, and recognizing the problems we will have in funding and so forth to get that technology in hand, it seems to me that 1990 is a good assumption for me to make, but that assumption is still invalid if we do not start doing some work now. And, therefore, I would say that it is appropriate for someone—and I would assume NASA—to maintain an active SST program essentially indefinitely until one comes into being. I do not think it is something that ought to be funded on a very high level basis or that it ought to be regarded as some kind of a crash program for various reasons, one of which is I do not think that the public at large is willing to fund any such thing, but neither do I think that we should sit back and assume that we can ignore this area of technology.
>
> In order to bring a new SST into being we are going to have to invest 2 to 3 billion dollars, and there is no one on the horizon at the moment who is willing to put up that kind of money. We have to be in a different position somehow before we can get people to invest that kind of money, either government or private. And that new position it seems to me would have to be that the technology has pretty well proved itself, which is done through government funding through NASA, dealing with engines, noise, pollution, and all the rest, and that the aviation industry itself had become more attractive to investors through successful operation of our subsonic carrier fleet, so that we get out of this period when people are very reluctant to finance new developments in aviation technology.

Frank Borman added this:

> . . . we should maintain an ongoing program of SST research. We do not see any immediate prospects of an economical, environmentally acceptable aircraft. However, we should recognize the possibility that the economic and environmental problems can be overcome and that this will result in a significant World market. In that event, we cannot afford to abdicate that market to foreign enterprises.

Ronald Smelt described the need for government involvement in a future SST project:

> . . . the Government must not only serve as a catalyst to secure an early launching of resources into a specific development program, but must also provide a substantial portion of the financial resources. This is especially true because the post-development manufacturing costs of a fleet of supersonic transports would, in and of itself, tax the financial capabilities of any single airframe company or group of companies. This is not to say that the industry cannot and will not provide any of the development funds for the supersonic transport, since clearly it can and should. Nor is it to say that the Government should not seek to recapture at least a part of its development stake through royalty payments on completed supersonic transport aircraft. It does imply, however, that Government must, in the first instance, supply the impetus for an early supersonic development program and must also be prepared to provide a major part of the financial resources for the program.

V/STOL

Frank Borman saw the need for an intercity air transportation system using small airports, located near city centers, and V/STOL aircraft:

> Over the long term, however, if we are to provide for the continued growth of air traffic, we will require more efficient use of available land resources. Therefore, we would recommend:
>
> Continued NASA efforts to improve the economic characteristics and environmental quality of short-field technology.
>
> DOT/FAA leadership in defining an airport/airways system which can effectively capitalize on the technology.

THE NEED FOR TRAINED MANPOWER

Dr. Ashley expressed concern for research and advanced education in the universities.

> . . . it was reported (recently) that college enrollment in aerospace engineering had declined by 70% during the preceding five years and that the number of autonomous departments had dropped from over 50 to 23. Although the former is slowly being reversed, these two trends have dangerous implications for aviation's future. With the economy beginning to recover, there are already indications of several years of higher demand for well-trained graduates than can possibly be supplied under present circumstances. Equally serious are the decimation and aging of a faculty complement which, in the 1950's and 1960's, produced a series of outstanding research discoveries far too numerous to be catalogued here.
>
> I am not recommending a massive infusion of federal dollars which would fully restore the university aeronautical establishment to the perhaps excessive levels of the 1960's. More modest and selective measures can, however, create levels of activity and of excellence commensurate with legitimate national needs.
>
> Let me offer a few specific proposals with high leverage toward these ends. First, the former NASA programs of academic fellowships and design traineeships should be revived at about the maximum size achieved during the late 1960's. Second, the very effective NASA university research program should be encouraged—not necessarily with large budgetary increases but because it can hold its own when not subjected to artificial constraints or to inappropriate demands for short-term accomplishments.
>
> A third measure, with a double payoff, would be to permit NASA and DOD aviation R. & D. activities to increase their professional manpower. The increased availability of research jobs would both stimulate more first-rate students to enter aerospace and revivify the agency's aging staff.

STATUS OF FOREIGN COMPETITION

Karl Harr speaking for the Aerospace Industries Association (AIA), described the growth of European industry in the following way:

> In sizing up the competition, we must recognize that the European aerospace industry is a collection of relatively small national corporations, some nationalized, some private, and all dependent on their national governments for new program development funding. A decade ago, the European aerospace industries were one-tenth the size of the U.S. aircraft industry. Today, however, they are approximately one-quarter the size of their U.S. counterpart. Aerospace employment in Europe, including military and commercial production, aircraft, engines and parts, is about 425,000 (half of whom are British) as compared to some 925,000 in the United States.

As for sales, "Europe's output increased 24 percent between 1965 and 1973; U.S. output fell 26 percent during this same time period." Thus it is clear that the Europeans are motivated to become more of a factor in the world market.

Dr. Stevens expanded on the reasons for this motivation as follows:

> For many years, the Europeans have been fragmented and had a hard time pulling together. Furthermore, recent decisions, such as the decision to purchase the F–16 have come as a blow to the European industry as a whole. Since 1972, however, they have been actively attempting, primarily through consortia and other cooperative arrangements, to pool their resources and their talents to meet head-on the challenge of the United States in this regard. The whole approach of trying to cope with rising R&D costs through consortium arrangements and through the pooling of resources is one of the factors that is going to have a big impact in the future.

Nevertheless, as an AIA Study points out, the U.S. has been very successful:

> Although total European aerospace sales have been increasing, market penetration in the commercial jet transport sector by European manufacturers has been declining over the past several years. The Europeans—that is the French and British in particular—have been less successful than their U.S. counterparts in the marketing and product support of commercial jet transports. Of particular concern to the Europeans is the loss of market in Europe itself since, historically, 75 percent of Europe's commercial jet output has been sold to European carriers.

Another reason for this had to do with American productivity. Although the labor force is about twice as large as that in Europe, sales are over four times as great—

> . . . over $26 billion as compared to under $6 billion for Europe. Even when differences in accounting procedures are reconciled, U.S. productivity in terms of sales per employee approaches two times that of the European aerospace industry, thus making U.S. products highly price competitive, even with foreign government support and subsidy.

Other factors were listed by Karl Harr:

> The domestic manufacturers have been able to offer a competitively priced, technically superior product tailored to the market requirements, adequate long-term, Government-supported export financing and suitable service support after sales. Moreover, a relatively free and open trading environment, with equality of marketing opportunity, has been available.

Richard Cohen listed:

The major policies supporting the development of aerospace capabilities within the five countries with the highest developed aerospace industries—France, West Germany, United Kingdom, Japan, and Canada—are designed to achieve improved competitiveness in the world market place as follows:

Government support of consortia team efforts to design, sell, support and finance families of commercial and military aircraft.

Develop management and manufacturing capabilities in order to achieve independent high technology capabilities. United States and/or foreign technology and know-how is imported through multinational development programs, licensing, and requirements for offset development and production to balance major procurements of foreign (U.S.) equipment by national agencies.

Government initiatives in rationalization or nationalization of aerospace industries in order to reduce uneconomic domestic competition, pool resources and development financing, standardize equipment for government/industry foreign sales efforts and increase productivity.

Government long-term budget planning and funding allocation for specific aerospace programs with expected export potential, recognizing that over the long-haul advanced-technology industries such as aerospace hold the key to future industrial expansion.

TECHNOLOGY

Dr. Stevens:

At the present time the Western Europeans, much to their credit, have at least four aircraft that are technically competitive with aircraft produced in the United States. This is an indication of where they now stand. All four aircraft were produced under multinational arrangements. These are the A-300 Airbus, which is important not only in its current configuration, but as a basis for derivatives that will go a long way in meeting emerging European requirements. Others are the VFW-614, a very low noise short takeoff and landing (STOL) aircraft that has been quite successful, and of course the Concorde, the SST. The fourth aircraft is the Netherlands-produced F-28 CTOL aircraft.

Despite this technical achievement in terms of specific aircraft, the Europeans are still faced with the problem of not being able to produce these aircraft on a cost competitive basis. This is due to a number of causes. In part it results from substantial nationalization and the maintenance of very large stable work forces. At the same time, the quantity of aircraft produced has not been large enough to make full use of that labor force, nor has it given them an opportunity to get far enough down on the learning curve to cut the costs of individual aircraft production as they proceed.

But from a technical viewpoint, these aircraft are competitive and, if they were sold in sufficient numbers, would become economically competitive.

The key to future European success is being able to cope with two things. The first is the acquisition of advanced engine technology. With the exception of Rolls Royce in the UK, U.S. companies have the lead in engine technology and for a number of years, engine technology has been the key to technological advantages in the aircraft business. The Europeans are now using the approach of trying to buy or, through cooperative arrangements, get access to that technology without themselves making the necessary very heavy research and development investment. We do not see that changing.

"The other major requirement if the Europeans are to become truly competitive with the U.S., is the development of an after-sales capability, i.e., that is maintaining the aircraft, providing spare parts, servicing and so on. They are beginning to establish this capability with their new aircraft which are on the market today, but they have yet to establish a worldwide after-sales capability comparable to the service that U.S. firms provide.

This after-sales capability has been a critical problem for the Soviets also. It is clearly one of the reasons why customers look askance at Soviet products in the aviation industry."

A good indicator of future intentions are the investments being made in test facilities. Dr. Stevens said:

There are clearly efforts under way abroad to improve the facilities for civil aviation R&D. The French and the Germans in particular are trying to improve

> their facilities. They largely have been left with World War II vintage wind tunnels. Those are being replaced now in both France and in Germany.
>
> The French, for example, will have the means in an improved tunnel for evaluating among other things ground effects vehicles; the German tunnel will be able to handle subsonic transport models, and so on. The Soviets are spending large amounts of money in trying to improve their facilities. Indeed, we have indications that the Soviets are spending large amounts of money for the improvements in capabilities in their aviation research.
>
> Part of the reason that the Soviets spend so much money is that the place strong emphasis on aircraft for military purposes. But increasingly now they are working on some of the larger transport aircraft. [They have] a full-scale wind tunnel, where actual size aircraft can be placed and tested with the propulsion going.
>
> The French and the Soviets also are improving their engine test facilities, the French particularly in conjunction with the SNECMA–GE engine arrangement.

As for the European program of research and technology, Dr. Stevens said:

> In looking at the whole range of basic technologies which are involved, it is clear that, with the exception of basic engine technology research, the Europeans and the Soviets are working across the board.
>
> Generally the United States is several years ahead, but the question is having the opportunity and motivation to apply this technology, much of which is driven and derived from the military.
>
> . . . in the case of propulsion, they have been willing to settle for getting access to United States technology. In the past, advances in propulsion have been responsible for reducing the costs of aircraft operation far beyond anything else. But, in the years ahead other aspects of aircraft technology are going to have a much, much more important part to play. So it makes sense to put your effort in some of these other areas at this time. The Europeans are aware of this and indeed, they are pursuing this sort of technological strategy in preparing for the future.
>
> Now the Western European investment in R&D is something like $600 to $700 million a year, which is greater than the comparable United States investment in R&D. So that to the extent that this consolidation and cooperation can continue, the U.S. is facing a formidable problem in terms of the basic investment going into research and development.

CHANGING MARKET CONDITIONS

As mentioned earlier, the share of the world market represented by sales to U.S. carriers is declining. Jack Steiner pointed out that, "ten years ago, foreign sales represented about 20 percent to 30 percent of the market. Today they represent 80 percent of the market." This trend is expected to continue because the demand for travel is increasing at a greater rate outside the U.S. William Rodenbaugh attributed this in part to following:

> The U.S. civil market is approaching saturation and, as a consequence, is limited in growth to the growth of the economy as a whole. Long-term evidence suggests that for 70 years the percent of disposable income spent on travel with common carriers has been a constant. Thus, as the airplane took business from land transport it enjoyed transient growth from market penetration in a saturated total—saturation of the air market was inevitable.

In spite of this, as brought out by the AIA study:

> The U.S. manufacturers have increased their market share over the past several years. In the late fifties, the U.S. had 72 percent and Europe had 28 percent of the Western market but by 1973 and 1974, the dollar value of U.S. deliveries represented fully 95 percent of all commercial jet deliveries.

As for the European market, U.S. penetration has increased there as well. Dr. Stevens noted that while the European market represented about 20 percent of world-wide traffic, sales of aircraft have been only about 10–12 percent of the total in the past several years.

> So there is evidence that their goal is to push their share of the business up to 20 percent in the next phase, the next round of civil aircraft sales.
>
> Insofar as the Soviets are concerned, they have an interest in entering the Western markets, but have had little success thus far. The vigor of their aircraft industry is largely spent in satisfying demands of Aeroflot, which is, of course, the largest carrier in the world. This provides them with enough recurrent business so that they are able to maintain a fairly vigorous civil program without being dependent upon the competitive markets of the Western world.

Karl Harr expressed similar concern that Europe will increase efforts to capture a greater market share.

> . . . the majority of foreign manufacturers are either government-owned or subsidized. Government support is justified, especially in France and Britain, by pointing to the anticipated $50 billion world market between 1975 and 1985 and noting that about 30 percent of this market will be European (fully 25 percent within the Common Market countries).
>
> If it fails to capture an adequate share of the market for its products, the European Community may yet suspend current methods of conducting trade in order to shore up the British and French aerospace industries. It will do so partly for non-commercial reasons, such as balance of payments concerns, technological fallout, defense policy, employment, prestige, and European cooperation. Traditionally, both France and the U.K. have adopted directed procurement policies, wherein the government directs the airline to buy certain equipment regardless of the airline's desires. Such practice in these two countries has been in evidence for some time and could well become European-wide. U.S. manufacturers estimate they have lost some $2 billion in sales over the past 15 years due to directed procurement.

Another important trend in European cooperation was described by Dr. Stevens:

> One of the significant events that has taken place as a result of this European cooperative effort has been an attempt to get the European airlines together and establish with some clarity what their specific airplane requirements will be in the next round of buys.
>
> What is happening in the European market is very important because it is coming up more quickly than is the case in the United States. Their requirements differ from those of the United States to some extent. Thus what is happening in European requirements is going to be important because they are going to be the driving force in this emerging market.

OUTLOOK

In summing up the outlook for foreign competition, Dr. Stevens said:

> . . . the multinational consortia will indeed provide a good basis for the R&D and everything that needs to go with that. That R&D is centered on those aspects of technology that are apt to have the greatest payoff in reducing operating costs. Furthermore, by 1985 that R&D work should enable the Europeans to be in a position to develop completely new aircraft that will be technologically competitive with the best the U.S. can provide with the possible exception of work in the engine area, where it is not clear that the Europeans will, by that time, have the capability for solving those problems.
>
> On the other hand, despite the Soviet efforts in a wide range of R&D and fancy technology in the military field, the peculiarities of the civil arena are such that it does not appear that they are going to be big competitors in that time period.
>
> There also are some advantages in terms of the financial support being given in Western Europe. That clearly will become a significant factor as we look ahead.
>
> . . . it is clear that in the next ten or 15 years, new civil aircraft are going to be produced by the Europeans which are technically of comparable quality

to those built by the United States. In the past we have had distinct advantages in that regard and they have largely given us the principal part of the market.

The near-term prospect s going to be competition for the European market as it is beginning to emerge and the Europeans have some distinct advantages which are going to make it difficult for United States industry. As a result, U.S. industry is going to have to rely on something more than just technical superiority in the years ahead.

With regard to the only other technologically advanced country, Japan, AIA concludes that their commitment is too small to promote a viable, competitive industry without joint venturing.

Dr. McLucas added the following:

Another question which I will touch on very briefly has to do with the possibility of loss of our pre-eminence with respect to foreign competition. Now there is no doubt that all of us want our United States aviation to maintain its leadership role. But I think we all must also accept that there is a place for our allies in this business because they have similar types of society, similar industrial capabilities, and it is unrealistic to assume that those capabilities will not be brought to bear in the world aviation market, and that they will not also capture a significant share of the overall business.

People ask: "Are we in danger of having our share of the market fall significantly?" And they cite innovations that have been made by foreign producers, and new designs that have been brought forth, and so on. And the worry that they have that these new designs might capture a larger share of the market and whether or not the United States has comparable designs to offer to these new markets. I think those are legitimate concerns, but I am not as worried as some people have indicated that they are, that we will not be able to maintain our lead. I think that the mere fact that we are concerned about it gives us the opportunity to do things about it.

TECHNOLOGY TRANSFER

Closely related to foreign competition considerations is the problem of international technology transfer. Simply stated, the U.S. possesses a wealth of aeronautical technology which is being sought by many other countries. And, as previously noted, the desire to retain foreign market penetration and the need to gain capital are motivating U.S. aerospace firms to participate in joint ventures overseas.

Thus, the dilemma facing American aerospace firms is how to maintain profitability without strengthening foreign competition by the transfer of aeronautical technology.

Having over-simplified, it must now be pointed out that technology transfer is a very illusive subject. As Dr. Weiss indicated, this is true because it is extremely difficult to define exactly what is being transferred and how it may benefit the receiving country. Yet, the consequences of technology transfer must be of considerable concern to R. & D. policymakers especially in view of these recent moves by U.S. manufacturers to form foreign partnerships. As Jack Hope stated:

> From our viewpoint, recognizing the changing environment for doing international business, we must face the fact that our private companies are in many instances facing corporations which are the chosen instruments of their governments. In order to compete, U.S. firms and the U.S. Government must devise guidelines on how to view the transfer of technology, on the basis that transfer of technology works against U.S. economic self-interest when the transfer results in a major advantage to an overseas competitor.

It is therefore appropriate to devote a section of this report to a discussion of the R&D related issues.

Definition Suggested

William Rodenbaugh, testifying for G.E., proposed the following breakdown:

> Technology is the combination of science, engineering, skills, and background applied to the conception, design, manufacture, and support of equipment. Technology is therefore a highly perishable commodity, which dissipates rapidly with time as the concept becomes broadly known and understood.
>
> Technology is exposed from its originator to potential customers via several routes: production items, licensing arrangements, and joint programs. All of these include technical data: each is subject to a different level of exposure.
>
> Although a production item represents the culmination of all the research, development, and production technologies associated with a high-technology industry, the sale of the product reveals only the final design. The iterative steps that result in the design, the testing techniques, and the critical management procedures that are an essential part of our technological lead are not compromised in the sale of hardware. In addition, the sale of currently available commercial equipment represents the sale of the product of past technology, and as such represents little threat to the original producer unless he deliberately chooses to halt research and development in his area of expertise. Thus the sales of "off the shelf" products normally are of small concern except for national defense or strategic issues, in which case other controls are effectively in place.

Licensing arrangements permit cooperative programs, but allow the option of withholding specific high technology information which might be deemed critical in the competitive sense. Because the licensee's gain—primarily time—can have possible leverage effects on his technology base for future efforts, screening processes are used to safeguard critical technology. In this screening process, the industry management exercises its proprietary judgment and recommends to the appropriate federal control agencies, for their review, what should and should not be included within the scope of a proposed licensing agreement. The team of industry and government thereby establishes in each case the appropriate safeguards.

In the case of joint venture or cooperative programs, the technology transfer may include advanced concepts, process and equipment information, marketing and management data, specialized manufacturing techniques, and the like. Such cases should be, and are currently, subjected to screening processes comparable to those used for licensing agreements. For joint ventures, however, individual review is required not only of the technology levels, but also of the nation's technical capabilities and the degree of technical interchange involved. In some instances, technology to be gained may be equivalent to or superior to the U.S. technology released.

Dr. Stevens suggested the following definition of the critical element of technology:

I was a member of an ad hoc Defense Department panel which looked at the question of technology transfer as it affected the Department of Defense. Engine technology was indeed one of the key issues we looked at. The engine manufacturers concluded that it is the management talent that allows an understanding of the implications of various design choices, in terms of production technology, that is perhaps the key ingredient. Now that type of expertise probably is not lost through the sale of engines, but indeed when through licensing arrangements and production agreements we go abroad, set up factories and participate in getting those factories working on an efficient basis, then technology transfer really does take place.

Examples of Policies Recommended

Jack Hope proposed the following:

Technology elements can be broadly categorized through their timeline: (1) basic concepts lead to (2) design, development, and production, culminating in (3) end products and service support. This tripartite nature of a technology life cycle gives us an opportunity to define the critical points for control of any transfer to overseas industry:

(1) The first portion of the cycle (*basic concepts*) concerns development of fundamental data pertinent to a wide spectrum of ideas related to aeronautical products. Generally, these ideas and data are widely disseminated. This is an area that has been historically uncontrolled and does not appear to warrant control from commercial considerations when the extreme lead time of our products is considered.

(2) The second portion of the cycle is that associated with the unique development of the basic concepts into hard technology that leads directly to the design, development, and production of unique end products. Generally, these data are kept closely within the industrial complex until "ready to do business". An exception is technology funded by the government, which receives general distribution unless classified.

(3) The third element of the cycle is that activity related to operation (maintenance and repair including spares). These data are generally open and directly transferred to the buyer (including foreign groups) in the normal course of business.

It appears that the most effective and, indeed, the most important technology control can be achieved in the second category—those areas related to the design, development, and production of end products. This, as we have seen, is also the area of largest capital investment and risk, so that corporate interests tend to impose the highest level of their own brand of security. Further, the livelihood and prestige of the individuals in the corporation, and of the corporation itself, are at stake. Thus, the motivation is very high for keeping the details of the important commercial aspects of the subject processes from all competitors, foreign and domestic. In general, therefore, it appears reasonable to depend upon U.S. industry to be concerned about "technology transfer" and to preserve our business leadership.

Frank Borman offered this:

We define research as a fundamental broadening of the base of knowledge. Traditionally, the results have been available to everyone, without regard for national boundaries, and we would strongly oppose any change in that concept.

With the other developed nations, our society faces the common concerns of finite limits on fossil fuel availability, preservation of environmental quality, and effective land use. Accommodating the continually increasing demand for air transportation in the face of these constraints is a challenge which we all face. To meet that challenge, we need a free and open exchange of research findings.

MILITARY FALL-OUT

Historical Perspective

Dr. McLucas:

Throughout the history of aviation developments the military has led the way to most of the advances because of the military's desire to gain advantage or to do impossible things. I would cite only a few examples, which are obvious to all of us, such as all metal construction, introduction of jet engines, radar, identification systems, data links, computers, displays, simulators, inertial navigation systems, satellites for weather, communication and navigation purposes, high strength lightweight materials, just to mention a few of the innovations which the military has brought to the field of aviation. I would cite things like the C–5 engine development, which led to the CF–6, which is used in commercial aviation now, and the JT–9–D, which is of the same generation. I would cite the B–1 engine as an example, which has led to the CFM–56 engine, which is being developed jointly by an American company and a foreign company, and is the same generation as the JT–10–D. But these are areas where indirectly we get an engine. Even though funding has to be provided outside of the Defense Department, we find that the basic work on high temperature technology has been done to allow these off-shoots to take place.

But looking at the overall effect of the military on the viability of our business, and particularly commercial transports of the past, a large fraction of those transports were made much more economically viable by military orders. The DC–3 is an example of an airplane that was losing money until the C–47 was bought in large quantities. We all know that the DC–4 and DC–6 got a boost from military orders and so did the Constellation. The Electra was a losing proposition until they came out with an antisubmarine patrol airplane.

So it seems to me the military has helped us in at least two very significant ways, first, in technology, and, second, in raising the production volume of many airplanes that were being built to the point where they made economic sense.

George Eads referred to an additional benefit of military R&D:

According to a recent study by Sydney Carroll, the U.S. Government has permitted aircraft manufacturers to earn rates of return on total investment on military aircraft projects that have been substantially in excess of the level required to allow these forms to attract capital. This has permitted these manufacturers to initiate commercial aircraft projects whose prospective rate of return, adjusted for risk, has been below that which ordinarily would be required. This has led in turn to a greater number of new commercial aircraft projects and consequently, to more technological change.

Dr. Currie briefly described a recent study that identified the tremendous effect over many years of military R&D on civil aircraft.

In 1972, the DOD, NASA, and DOT completed a detailed study of aeronautical progress since 1925 entitled "Research and Development Contributions to Aviation Progress" (RADCAP). That study identified 51 significant technological advances made in U.S. aviation during the period 1925 to 1972 and it found that military sponshorship was responsible for 35 of them. They range over a spectrum from high-octane aircraft fuel which was first applied to the civil air fleet in 1946, to inertial navigation applied in 1967, and most recently the high bypass ratio turbofan developed for our C–5 program which spawned the current generation of wide body civil transports, recognized world-wide for their productivity and passenger comfort.

Parallel Needs

Dr. Currie identified the major technology areas in which military and civil interests converge:

A. Both sectors have a strong interest in the conservation of fuel through improving the efficiency of aircraft.

B. The area of air transport has been one of considerable commonality of interest in the past. For example:

> As we look to the future prospects for large logistics aircraft, the advantages of composite structures, active controls and drag reduction indicate there still remains an economy of large scale which we have not exploited to the fullest in current widebody aircraft, including the C–5. However, economic assessment of payoff indiactes that exploitation of these technologies for evolutionary large aircraft configurations cannot offer sufficient improvement over derivatives of current systems to warrant new aircraft programs. We need a breakthrough before a new large logistics transport can be justified.
>
> Such a breakthrough may come in a revaluation of water as the most effective base for large aircraft. Current research in ground effects may result in a significant reduction in the drag associated with seaplane operations. This could result in very large cargo aircraft that will expand air cargo to a major element in international commerce.

C. There is a parallel interest in V/STOL aircraft that combine the flexibility of the helicopter with efficient high subsonic cruise.

D. Helicopter noise reduction is important to both sectors.

E. In the area of navigation, the military is currently developing a worldwide satellite navigation and positioning system called NAVSTAR. There are many indicators that this system will have significant applications to both commercial and general aviation.

F. The DOD is concerned with stratospheric pollution that is caused by aircraft engine emissions.

G. There is a continuing need for modernized test facilities by both military and civil aircraft designers. Considerable effort has been expended to assure that these are built so as to be usable by both.

Divergent Needs

Dr. Currie also listed areas where military and civil needs diverge:

A. The DOD has a continuing requirement for increased maneuverability for its tactical aircraft.

B. There is no equivalent need in the civil sector to reduce radar, optical and infra-red signature of combat aircraft.

C. The military is working on small unmanned aircraft such as cruise missiles and remotely piloted vehicles.

D. Nap-of-the-earth flying is a development with no civil application.

General Trend

Dr. McLucas summed up the general trend in benefits from military R&D to civil aviation in the following way:

> . . . I believe that they will continue to assist us in future aviation development. However, the nature of the relationship between military and civil research and development has changed. The days of "direct" transfers of technology and equipment to the civil side, such as the B–52 to the Boeing 707 are largely gone. These are the days of derivatives, where concepts developed in the DOD are being adapted by civil R&D to produce commercial designs. Even this source, however, appears to be drying up. New military aircraft are being designed to fly faster and carry compact weapon systems. These goals are not the goals of civil aircraft today and this is the crux of the problem. We do not share identical design objectives with the military. Today, our new civil aircraft are expected to be efficient, quiet, clean, as well as safe. While DOD shares these objectives, they are viewed from the perspective of military mission accomplishment.

Dr. Cortright reiterated this:

> Unfortunately, the contributions of military technology to civil aviation are continually decreasing due to divergent needs, and must be replaced by programs in our civil aviation agencies, NASA and FAA.

ADDITIONAL VIEWS OF HON. BARRY GOLDWATER, JR.

Thoughts and Comments on the "Future of Aviation" Hearings

The aviation industry, including all its appurtenant activities, has made a profound contribution to the welfare of our nation in the past, and if permitted, may make even more dramatic contributions in the future.

The problems facing the industry are legion. As legislators however, our primary role is in policy formation rather than specific problem solving.

The recent hearings on the future of aviation have emphasized major problems, mostly economic and political, which, if ignored, will lead to loss of our longstanding preeminence in the field. This loss will have severe internal economic repercussions in addition to the loss of international prestige.

While the economic problems primarily are the purview of other committees, their import is such that future development in the technology area will be seriously handicapped, if not prevented, if these economic problems are not rectified.

Technology development, coupled with aggressive management and marketing, has propelled our aviation industry, including both aircraft manufacture and airline operations into a position whereby it is second only to agriculture in its positive contribution to the U.S. international balance of payments.

Dealing first with the economic, existing regulation of the airline industry must certainly be recognized as a mixed blessing. Total immediate deregulation would obviously be catastrophic, but modest steps in that direction would no doubt have beneficial and stimulating effects. As a starter, I would recommend some immediate steps to deregulate the fare structure and restore the influence of the marketplace to the airline industry. I believe that counter to the fears of some, a competitive fare structure would tend to stimulate better seat factors and thereby provide improved revenues which are the key to most other industry economic problems.

Technology development has been the single most significant factor in our rise to prominence in every facet of the aviation industry. This development can provide benefit in the future, as it has in the past, from intense cooperation with, and application of, military research and technology. Contrary to the thoughts of some, a large part of military aviation research and technology continues to have direct application and fallout to civil aviation, both general and commercial, This is true even though no DOD aircraft funding supports the civil sector directly. It is because the breadth of the military effort is sufficiently great in context to include application to civil needs. Technology development, fortunately, is insensitive to the political implications of its application.

Just a few of the more significant current military technology programs with civil aviation benefit implications are:

The advanced medium (STOL) transport (AMST) which will undoubtedly have application to replacement short haul commercial systems.

Rotor Systems Research aircraft and the advancing blade concept helicopter with demonstrated noise reduction potential, for application to commuter and cargo airline needs.

Variable cycle engine development.

Composite materials technology.

Nor is the technology flow just in one direction—for example, one aircraft manufacturer is using the nose section of his current production wide body jet in his version of the AMST.

We *must* maintain this technical superiority that has been the keystone to our preeminence if our aviation industry is to remain in the number one spot it has enjoyed in the past.

This in turn requires continuing support of strong R&D programs, both military and civil. The role of NASA as the focal point for aviation technology should be more clearly defined and strengthened. The unique systems engineering management capability that was and continues to be greatly responsible for our great space achievements should be applied to these current problems of our aviation industry.

Much of the testimony presented during the hearings was preoccupied with the economic difficulties facing the industry. Of all of these, none seems to be more important than that of the unrealistic depreciation schedules under which not only the aviation industry but *all* American industry is laboring.

Traditionally, depreciation charges are a major source of funds for replacement of equipment when the original equipment reaches the end of its useful life. In a stable economy with minimum inflation, a depreciation schedule based on acquisition cost has worked reasonably well for this purpose. Now, however, depreciation allowances do not generate sufficient funds to replace plant and/or equipment because the same or comparable equipment costs much more because of inflation. At the same time, this unrealistically low depreciation charge results in artifically high corporate income taxes—a further burden on an already troubled industry. Even at reasonable levels of inflation over the next ten years, the effect of this discrepancy will be terribly severe. It hits all facets of the aviation industry—airlines, civil aircraft manufacturers, military/aerospace firms and general aviation equipment companies.

It is significant to note that major industrial countries competing with the United States already recognize *real* depreciation costs (replacement cost) (West Germany and Japan) or are moving officially toward such recognition (Great Britain) as the basis for depreciation schedules.

Another and very major economic problem facing the industry is international competition from cartels or nationalized corporations that in effect are backed by the total resources of the nations they represent. I do not believe that our antitrust regulations ever contemplated this kind of competitive environment. The "Business Review Procedure" presently utilized by the Anti Trust Division of the Department of Justice may have been satisfactory in the past for intra national joint venture considerations, but I feel that the present conditions facing the industry demand a fresh look at regulations covering joint ventures pertaining to new equipment development whether for domestic or international competition.

It has been shown that in addition to the inadequate depreciation schedule and the effects of cartelized and nationalized foreign competition, capital costs of new programs for civil air transports now range from 1 to 5 billion dollars, many times the net worth of the potential individual aircraft manufacturer, with a payback period exceeding ten years. Neither investors nor lenders who are prudent would be attracted to provide capital under those circumstances.

A bold, multi-faceted Federal program appears to be necessary if a bright future for the aviation industry is to be assured. It should include:

A thorough examination of the capital formation problems of the industry as a precursor to realistic, corrective legislation in the corporate taxation realm.

Innovative antitrust legislation that recognizes the facts of life concerning the unfair impact of nationalized and cartelized foreign competition.

Increased emphasis and funding for R&D, both civil and military, in the aviation/aerospace field to insure that our past technical leadership does not slowly erode.

Phased but steady deregulation of the airline industry to permit the full effect of the competitive marketplace to be felt, thus permitting the customer rather than a regulatory agency to decide what he wants to buy for his travel dollar.

Consideration of a high priority program, probably managed by NASA and operated along the lines of the Space Program to ensure the continued leadership of the United States in the design and manufacture of the highest priority major new equipment needs of the aviation industry (e.g. perhaps an advanced STOL or VTOL aircraft or a hybrid capability aircraft for heavy lift that could support our energy source development efforts in remote areas).

The significant technical advances in airfield and long distance aircraft operations warrants continued and probably accelerated support of FAA programs both financial and legislative.

In all of the above areas, the cooperation and support of the Office of Management and Budget should be stressed to insure that both the leadership role and economic benefits our national economy requires continues to accrue to our nation from the aviation industry.

APPENDIX I

List of Hearing Witnesses on the Future of Aviation

Tuesday, May 4, 1976:
- Honorable William T. Coleman, Jr.—Secretary of Transportation
- Dr. Aaron Gellman—President, Gellman Research Associates

Wednesday, May 5, 1976:
- Mr. Frederick W. Bradley, Jr.—Vice President, Citibank, N.A.
- Mr. William M. Magruder—Executive Vice President, Piedmont Airlines

Thursday, May 6, 1976:
- Dr. James C. Fletcher—Administrator, National Aeronautics and Space Administration
- Dr. Edgar M. Cortright—President, American Institute of Aeronautics and Astronautics

Tuesday, May 11, 1976:
- Dr. John McLucas—Administrator, Federal Aviation Administration
- Mr. John E. Steiner—Vice President, Boeing Commercial Airplane Company

Wednesday, May 12 ,1976:
- Dr. Sayre Stevens—Acting Director for Science and Technology, Central Intelligence Agency
- Colonel Frank Borman—President, Eastern Airlines
- Ms. Mimi Cutler—Aviation Consumer Action Project

Thursday, May 13, 1976:
- Dr. Gus Weiss—Staff, Council on International Economic Policy, The White House
- Mr. Jack Hope—General Manager, CFM Program Department, General Electric Company
- Dr. Malcolm Currie—Director, Defense Research & Engineering, Department of Defense

Tuesday, May 18, 1976:
- Mr. Karl Harr—President, Aerospace Industries Association
- General Clifton von Kann—Vice President, Air Transport Association

Thursday, May 20, 1976:
- Mr. Russell Train—Administrator, Environmental Protection Agency
- Mr. Thomas Kauper—Assistant Attorney General, Department of Justice
- Mr. Edward Stimpson—President, General Aviation Manufacturers Association
- Dr. James Miller—Assistant Director for Government Operations and Research, Council on Wage and Price Stability, The White House

APPENDIX II

List of Contributors of Papers on the Future of Aviation

1. Prof. Neil A. Armstrong—Professor of Aerospace Engineering, University of Cincinnati, also advisory member of Kenton County Airport Board, Cincinnati
2. Prof. Holt Ashley—Professor of Aeronautics and Astronautics and Mechanical Engineering, Stanford University
3. Mr. Harold S. Becker—Vice President and Treasurer, The Futures Group
4. Mr. John G. Borger—Vice President and Chief Engineer, Pan American World Airways, Inc.
5. Mr. John C. Brizendine—President, Douglas Aircraft Company Division, McDonnell Douglas Corporation.
6. Dr. Robert H. Cannon, Jr.—Chairman, Division of Engineering and Applied Science, California Institute of Technology
7. Mr. Richard E. Cohen—Bureau of International Commerce, U.S. Department of Commerce
8. Mr. Harry E. Colwell III—Vice President, Chase Manhattan Bank, N.A. and Division Executive of its Aerospace Division
9. Mr. Andrew de Voursney—Group Vice President—Finance and Planning, United Airlines
10. Mr. George C. Eads—Executive Director, National Commission on Supplies and Shortages
11. Mr. Glen A. Gilbert—Glen A. Gilbert & Associates, aviation consultants
12. Prof. Paul Gray—Chairman, Department of Quantitative Business Analysis, University of Southern California
13. Mr. J. C. Green—Manager of Operations Analysis, Sikorsky Aircraft
14. Mr. Malcolm Harned—President, Cessna Aircraft Company
15. Mr. Willis M. Hawkins—Senior Advisor, Lockheed Aircraft Corporation
16. Dr. Klaus P. Heiss—President, ECON, Incorporated
17. Prof. Robert Horonjeff—Professor of Transportation Engineering, University of California, Berkeley
18. Mr. David R. Israel—Technical Assistant to the Administrator, Energy Research and Development Administration
19. Mr. Franklin W. Kolk—Vice President—Technological Development, American Airlines
20. Mr. John F. Leyden—President, Professional Air Traffic Controllers Organization
21. Mr. Hans Mark—Director, Ames Research Center, National Aeronautics and Space Administration
22. Dr. Richard R. Nelson—Professor of Economics, Yale University Institute for Social and Policy Studies

23. Mr. William H. Ottley—Executive Director, National Pilots Association
24. Mr. Frank N. Piasecki—Piasecki Aircraft Corporation
25. Mr. Paul H. Poberezny—President, Experimental Aircraft Association
26. Mr. Simon Ramo—Vice Chairman of the Board and Chairman of the Executive Committee, TRW
27. Mr. Robert A. Richardson—Executive Director, Helicopter Association of America
28. Mr. John E. Robson—Chairman, Civil Aeronautics Board
29. Mr. R. W. Rummel—Vice President, Technical Development, Trans World Airlines
30. Mr. Abe Silverstein—Retired Director, Lewis Research Center, National Aeronautics and Space Administration
31. Mr. Ronald Smelt—Vice President and Chief Scientist, Lockheed Aircraft Corporation
32. Mr. Floyd E. Smith—International President, International Association of Machinists and Aerospace Workers
33. Dr. H. Guyford Stever—Director, National Science Foundation
34. Mr. T. R. Stuelpnagel—Vice President and General Manager, Hughes Helicopters
35. Mr. Charles M. Walker—Assistant Secretary of the Treasurer
36. Mr. Henry C. Wallich—Member, Board of Governors of the Federal Reserve System
37. Mr. John H. Winant—President, National Business Aircraft Association

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